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AFGL-TR-77-0074

EVALUATION STUDIES OF TELEMETRY SYSTEM COMPONENTS

by
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SCIENTIFIC REPORT NO. 1

11 January 1977

Prepared for

Air Force Geophysics Laboratory
Air Force Systems Command
United States Air Force
Hanscom AFB, Massachusetts 01731

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REPORT DOCUMENTATION PAGE	READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER: AFGL-TR-77-0074	2. GOVT ACCESSION NO. / 3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle): Evaluation Studies of Telemetry System Components,	5. TYPE OF REPORT & PERIOD COVERED: Scientific Report #1 (13 Feb 76 — 10 Jan 77)
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s): Richard H. Marks	8. CONTRACT OR GRANT NUMBER(s): F19628-76-C-0111
9. PERFORMING ORGANIZATION NAME AND ADDRESS: Northeastern University, Electronics Research Laboratory, Boston, MA 02115	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS: 62101F / 76590102 / 01
11. CONTROLLING OFFICE NAME AND ADDRESS: Air Force Geophysics Laboratory, Hanscom AFB, Massachusetts 01731, Monitor/Eben M. Hiscock/LCS	12. REPORT DATE: 11 January 1977
	13. NUMBER OF PAGES: 48
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office): Scientific-1	15. SECURITY CLASS. (of this report): Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution limited to U.S. Government agencies only; (Proprietary Information; Test and Evaluation; Information which would be unfairly prejudicial to the manufacturer); 30 March 1977. Other requests for this document must be referred to AFGL, LCS, Hanscom AFB, Massachusetts 01731.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Telemetry component evaluation
Airborne equipment
RF transmitters
Test equipment

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report contains the results of a program for the evaluation of commercial airborne telemetry system equipment. A number of RF telemetry transmitters were tested. The test procedures and results are given for all the equipment evaluated.

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INTRODUCTION

A comparative evaluation of commercial telemetry equipment is being conducted under contract from Air Force Geophysics Laboratory, Bedford, Massachusetts (contract F19628-76-C-0111) from 13 February 1976 through the present. During the span of this contract, major manufacturers of certain categories of airborne system components are asked to submit their products on consignment. In each instance the electrical characteristics are measured and compared against the manufacturer's published specifications. The results of these tests are classified as proprietary information and made available to AFGL and the individual manufacturers concerned. Complete results of all components tested during the period 13 February 1976 through 11 January 1977 are included in this report.

This evaluation program was initiated in April 1958 (under contract AF19(604)-3506) as a means of insuring the receipt of working units. Since that time, the program has expanded to the point where all manufacturers are invited to participate. RF Transmitters and Subcarrier Oscillators are the two main categories of components tested to date. The first section of this report details the test performed, equipment used and the procedures followed. The second section contains a tabulation of the equipment tested and the resulting data.

RF Telemetry Transmitters

A. Evaluation Test Procedure for RF Telemetry Transmitter

Test 1. Time Drift

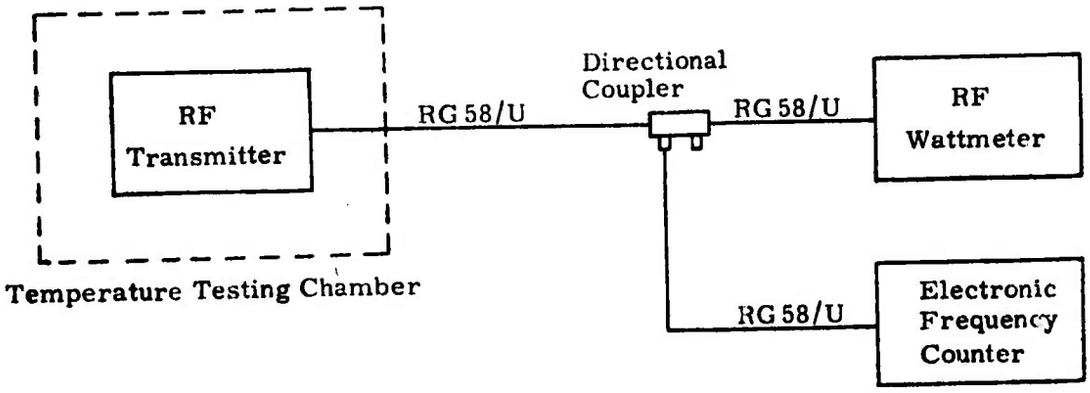

FIGURE 1.

Step 1. Place the RF Transmitter inside the temperature testing chamber. Set the temperature at +30°C. Wire test equipment as shown in Figure 1. Ground the modulation input terminal. Use recommended B+ Supply voltage. Without allowing a warm-up period, turn on the supply voltage. Measure the output frequency and output power at the time intervals shown on Transmitter Data Sheet 1. Record the following observations on Data Sheet 1:

(a) Time of observation;
(b) Output frequency in MHz;
(c) Output power in watts.

Step 2. Results

(a) Plot the Frequency Drift in % of Carrier Frequency, f_c, versus Time on Graph Sheet 1;
(b) Plot the Output Power versus Time on Graph Sheet 1.

Evaluation Tests - Data Sheet 1

RF Telemetry Transmitter

Make: _____ ; **Type:** _____ ; **Serial Number:** _____ ;

Carrier Frequency fc: _____ MHz ; **Date:** _____ ; **By:** _____ :

I. **Time Drift**

Time Minutes	Output Frequency Mhz	Drift in % of Carrier Frequency	Output Power Watts
0			
1			
2			
3			
4			
5			
10			
15			
20			
25			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			

II. **Temperature Stability**

Temperature °C	Output Frequency Mhz	Shift in % of Carrier Frequency	Output Power Watts	Input Current	Incidental FM

III. **B+ Voltage Regulation**

B+ Voltage Variation %	Output Frequency Mhz	Shift in % of Carrier Frequency	Output Power Watts
+10			
+5			
0			
-5			
-10			

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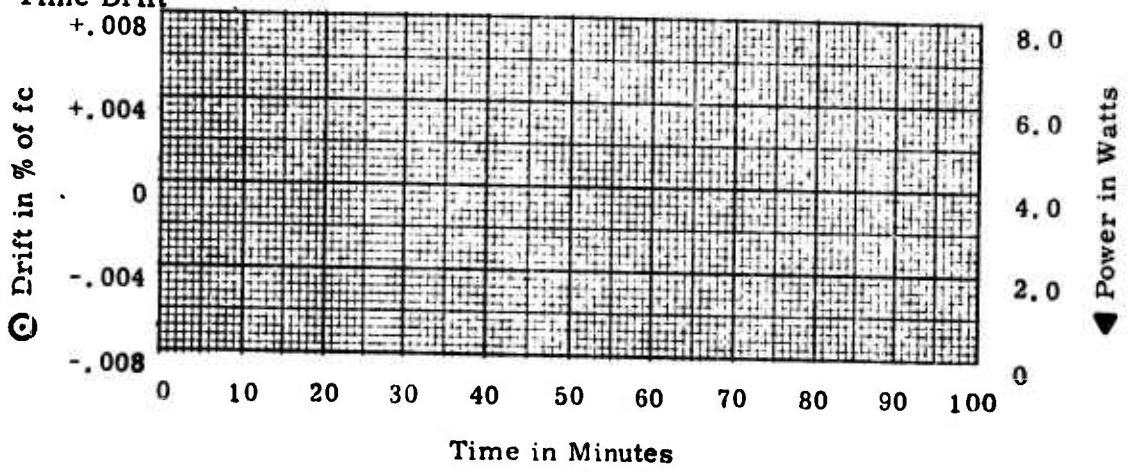
Evaluation Tests - RF Telemetry Transmitter - Sheet 1

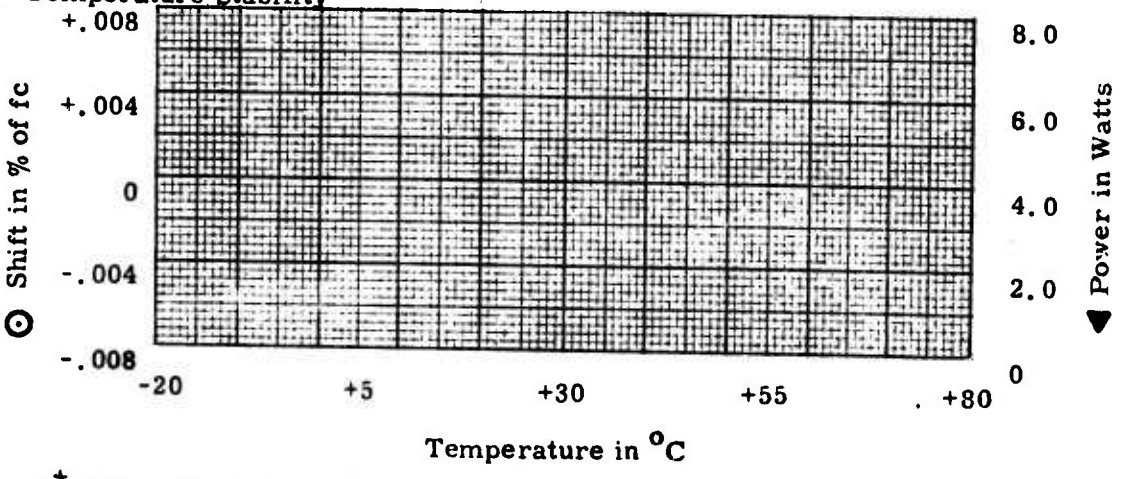
Make:_____; Type:_____; Serial Number:_____;

Carrier Frequency fc:_____ MHz; Date:_____; By:_____;

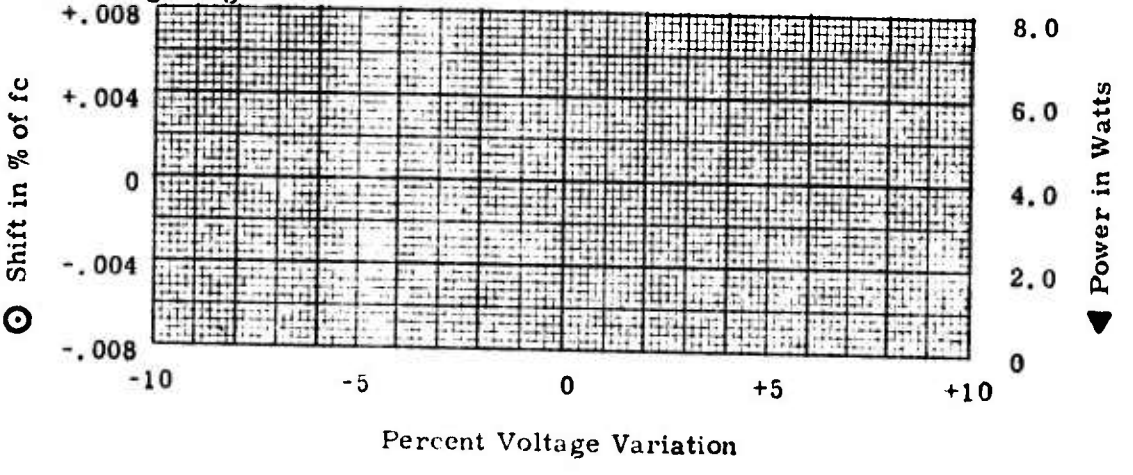
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation



Test II. Temperature Stability Tests

Step 1. With the temperature testing chamber set at +30°C, wire test equipment as shown in Figure 1. Using recommended B+ supply voltage, allow a sufficient warm-up period before proceeding to Step 2.

Step 2. Ground the modulation input terminal of the transmitter. Measure the output power and the carrier frequency. Record the following observations on Data Sheet 1:

(a) Temperature in °C;
(b) Output power in watts;
(c) Output frequency in MHz;
(d) Input current in amps;
(e) Incidental FM in Hz.

Step 3. Repeat Steps 1 and 2 for the following temperatures: -20°C, +5°C, 55°C and 80°C.

Step 4. Calculate the frequency shift in % of fc. Plot the % frequency shift versus temperature on Graph Sheet 1. Also plot the output power versus temperature on Graph Sheet 1.

Test III. Voltage Regulation

Step 1. Use equipment set up shown in Figure 1. With the temperature of the chamber set at 30°C, vary the B+ supply voltage from -10% to +10%. Record and compute the following on Data Sheet 1.

(a) B+ supply in % of recommended value;
(b) Frequency shift in % of fc;
(c) Output power in watts.

Step 2. Results

Plot the % frequency shift and output power versus B+ supply variations on Graph Sheet 1.

Tests IV and V. Modulation Response and Linearity Tests

Step 1. With the temperature testing chamber set at +30°C, wire the test equipment as shown in Figure 2. Using recommended B+ supply voltage, allow a sufficient warm-up period before proceeding to Step 2.

Step 2. Set the audio oscillator at each of the modulating frequencies indicated in Data Sheet 2A. Adjust the output level of the oscillator for the nominal deviation (E_4). Repeat for 25%, 50%, 75% and 125% of nominal deviation. Record the following observations on Data Sheet 2A.

(a) Oven temperature in °C;
(b) Modulating voltages E_1, E_2, E_3, E_4, E_5;
(c) Frequency deviation in KHz;
(d) Distortion.

Step 3. Repeat Steps 1 and 2 using modulating voltage E_4, for the following temperatures; -20°C, +5°C, 55°C and 80°C and record on Data Sheet 2.

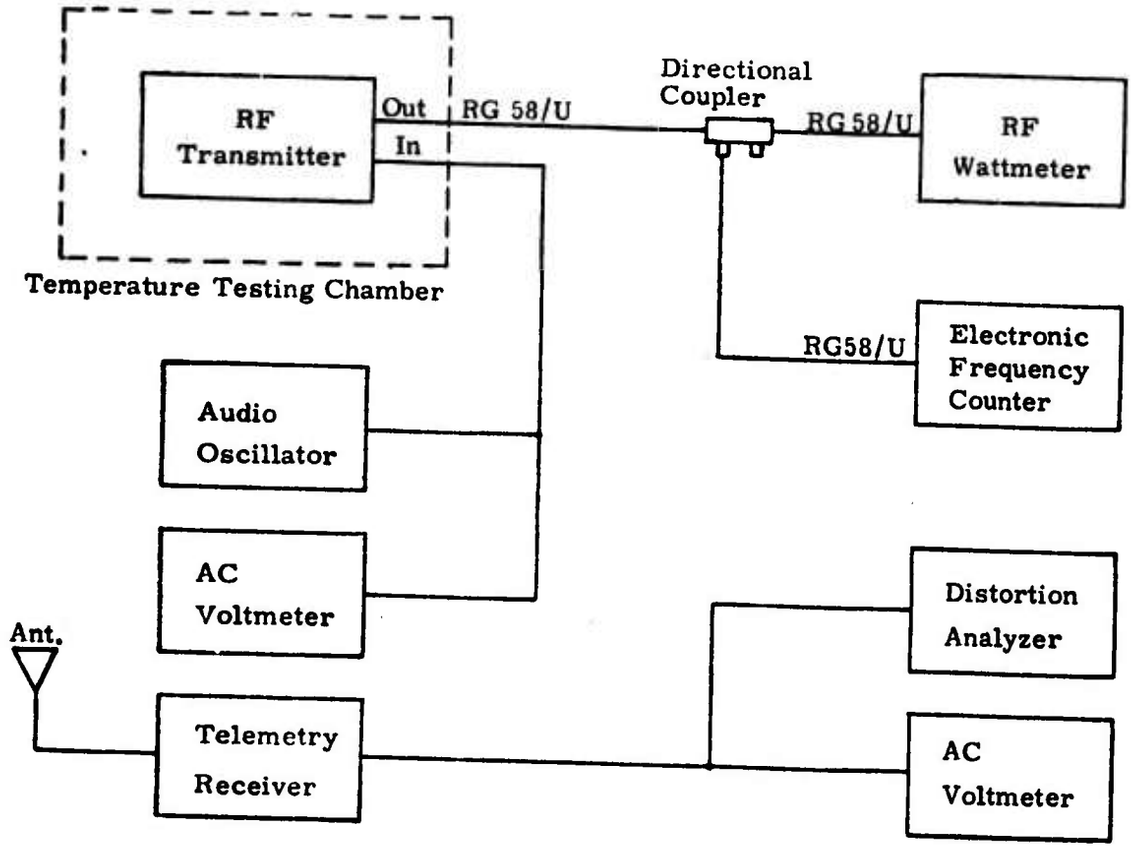

RF
Transmitter
Out
In
RG 58/U
Directional
Coupler
RG 58/U
RF
Wattmeter
Temperature Testing Chamber
RG58/U
Electronic
Frequency
Counter
Audio
Oscillator
AC
Voltmeter
Distortion
Analyzer
Ant.
Telemetry
Receiver
AC
Voltmeter

FIGURE 2

Evaluation Tests - Data Sheet

RF Telemetry Transmitter

Make: _____; Type: _____; Serial No: _____;

Carrier Frequency fc: _____; Mhz Date: _____; By: _____;

II MODULATION RESPONSE VS TEMPERATURE

T = _____ ^{o}c; Modulation Voltage = _____ Volts

Modulating Frequency fm Khz	Deviation Δfc in Khz	DB = 20 Log $\frac{\Delta fc}{\Delta fco}$		Distortion
		Δfc/Δfco	DB	
.4				
.6				
.8				
1				
2				
4				
6				
8				
10				
20				
40				
60				
80				
100				
200				
300				
400				
500				

$$\Delta fco = \sqrt{\Delta fc \text{ Min} \times \Delta fc \text{ Max}}$$

Evaluation Tests - Data Sheet 2A

RF Telemetry Transmitter

Make: _____; Type: _____; Serial No: _____;

Carrier Frequency f_c: _____; Mhz Date: _____; By: _____;

LINEARITY VS FREQUENCY

T = AMBIENT

Modulating Frequency fm Khz	Deviation Δfc in Khz					Distortion
	E_1	E_2	E_3	E_4	E_5	
.4						
.6						
.8						
1						
2						
4						
6						
8						
10						
20						
40						
60						
80						
100						
200						
300						
400						
500						

Step 4. Calculations and Results

(a) Linearity at Ambient - Plot deviation versus modulating frequency for the five modulating voltages on Graph Sheet 2.

(b) Modulation Response - Calculate the modulation response in db using information from Data Sheet 2. Plot modulation response versus modulating frequency for the five different temperatures on Graph Sheet 2.

Test VI. Spurious Emission (Antenna Conducted)

Step 1. Tune the band elimination filter for maximum attenuation at the carrier frequency of the transmitter under test. The amount of attenuation should be such that the transmitter rf output is attenuated to -40dbm. Make a frequency response of the filter and spectrum analyzer and plot the response curve.

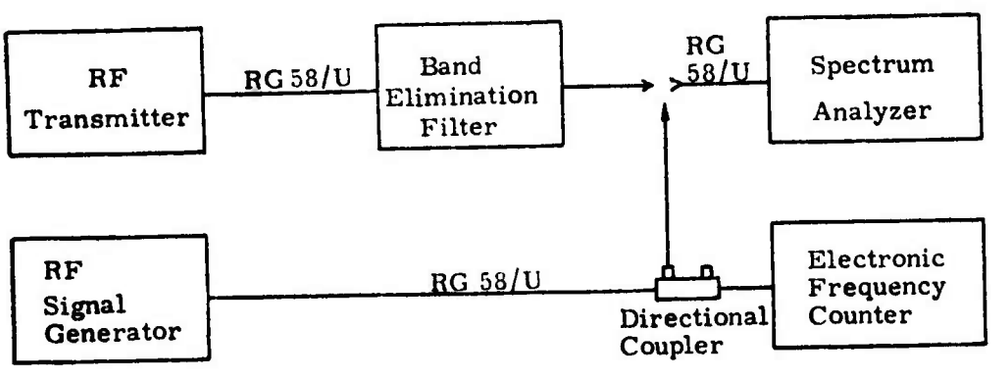


FIGURE 3.

Step 2. Use equipment set-up shown in Figure 3. Identify and measure the spurious frequencies present using the spectrum analyzer. The frequency may be measured accurately by comparison with a known frequency from the signal generator.

Step 3. Use the frequency response obtained in Step 1 to make appropriate amplitude corrections. Record the frequencies and amplitudes of the spurious emissions on Result Sheet 3.

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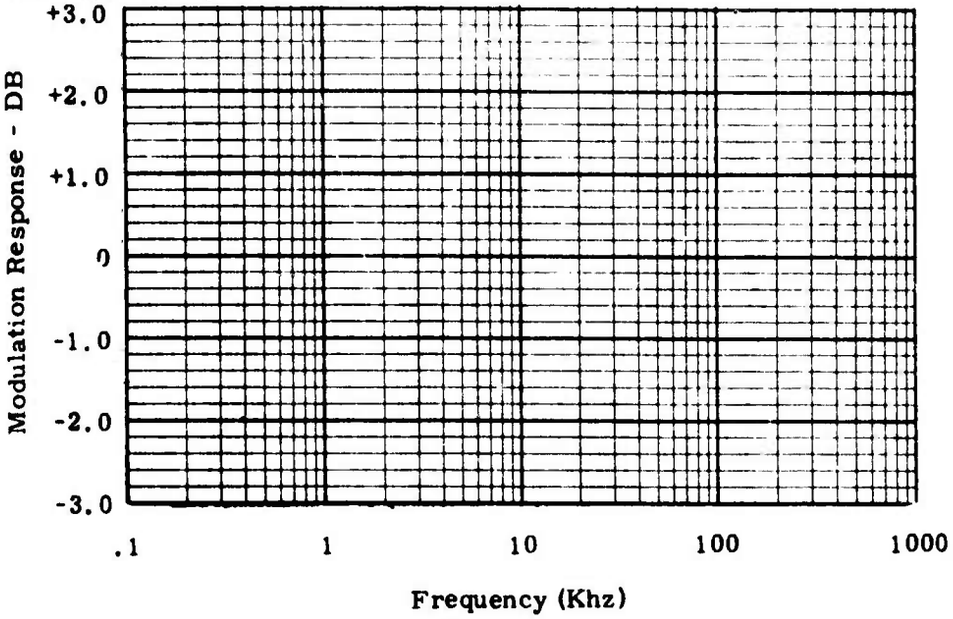
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

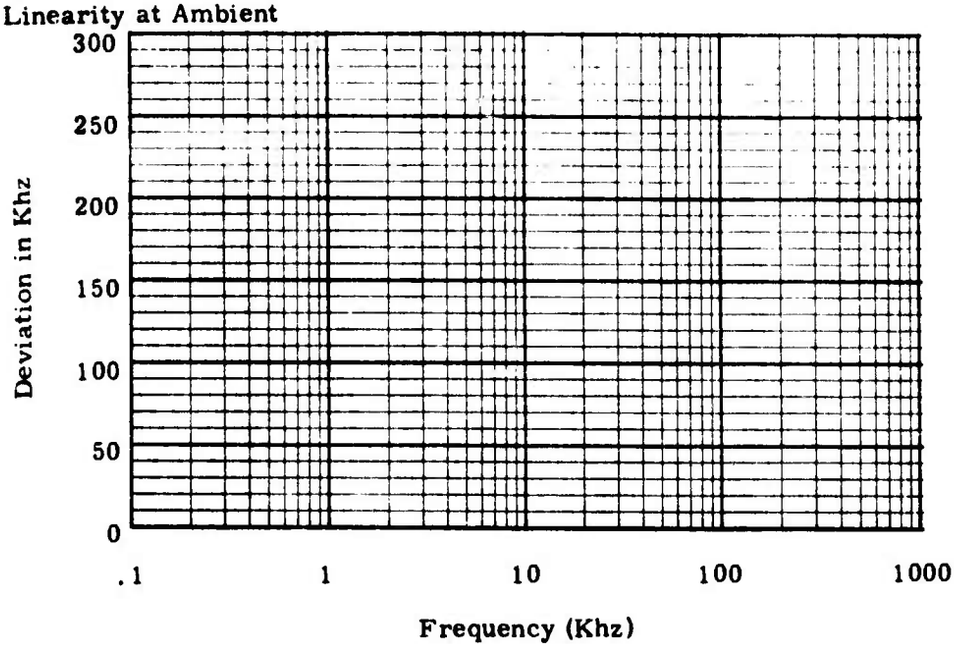
Make:_____; Type:_____; Serial Number:_____;

Carrier Frequency fc:_____ MHz; Date:_____; By:_____;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make:_____; Type:_____, Serial Number:_____;

Carrier Frequency fc:_____MHz; Date:_____; By:_____;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10 log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion _____
2. Incidental FM _____
3. Power Requirement _____
4. Efficiency _____
5. O.C. & S.C. Protection _____
6. Other Checks _____

_____

Test V11. Miscellaneous

Step 1. Record maximum distortion from Data Sheet 2.

Step 2. Record maximum incidental FM from Data Sheet 1.

Step 3. Compute power requirements and efficiency from information on Data Sheet 1.

Step 4. Perform open circuit and short circuit tests and record if the transmitter is within the manufacturer's specifications.

B. Test Results for RF Transmitters

Table 1 contains information regarding the manufacture, type and number of transmitters tested during the period of 13 February 1976 to 11 January 1977. The remainder of this chapter contains the test results for each transmitter in the order listed in the table.

Table 1

Manufacturer	Type	Number Tested
Conic	CTB-200-0.5H	3
Conic	CTP-402	1
Vector	T105S	4
Vector	T110 TVS	1
Vector	T202S	1

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Conic; Type: CTB-200 Series;

Manufacturer's Specifications

Frequency Range	Crystal Controlled (single frequency), VHF Telemetry Band 215-260 mc (other frequencies available on special order).
Center Frequency Stability	0.01% under environmental operating conditions.
Power Output	Choice of 0.5, 1.5 or 5 watts nominal - Terminated into 50 ohms resistive with 28 VDC supply.
Power Requirements	28 VDC at 1.0 amperes maximum. Can be operated at voltages from 24-30 VDC.
Radio Frequency Interference	Satisfies the requirements of IRIG 106-66 for antenna conducted and radiated and MIL-I-26600 for box and power line conducted and radiated.
Construction	Modular printed circuit construction. Boxes and cover are cast with integral shielding provided by the casting.
Environmental	Temperature range: $-30^{o}C$ to $+80^{o}C$. Shock: Each axis, 100 G for 11 milliseconds duration. Pressure: Tested to 250,000 ft. Vibration: Each axis, 20 G peak from 20 cps to 2000 cps. Length 3.6 inches - Width 1.8 inches - Height 1.3 inches. Less than 6 ounces.
Case Size	Length 3.6 inches - Width 1.8 inches - Height 1.3 inches.
Weight	Less than 6 ounces.

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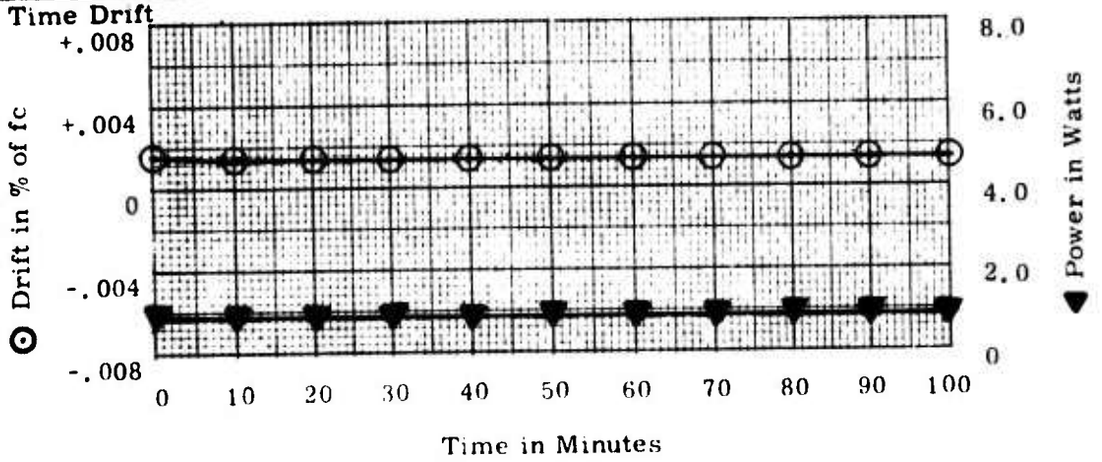
Evaluation Tests - RF Telemetry Transmitter - Sheet 1

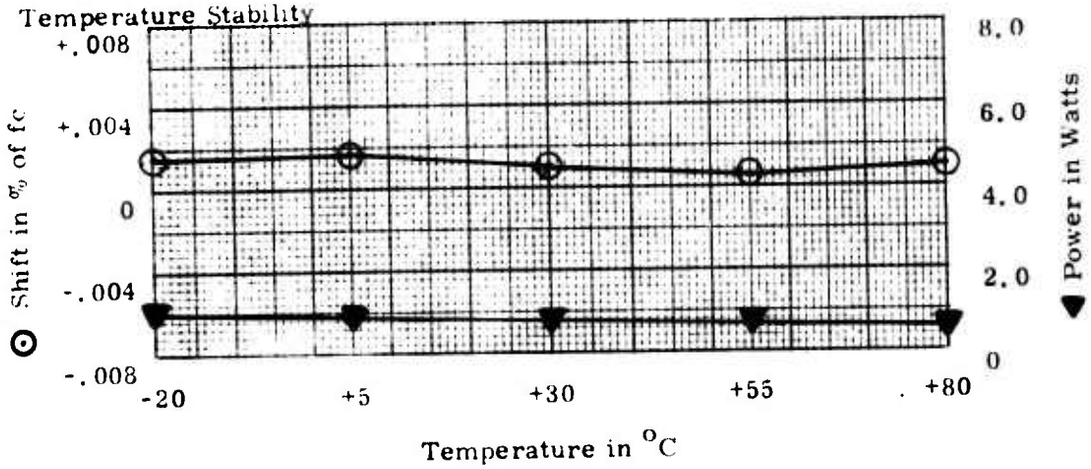
Make: CONIC ; Type: CTB-200-0.5H ; Serial Number: 200B277 ;

Carrier Frequency fc: 242.0 MHz; Date: 6/28/76 ; By: KYL ;

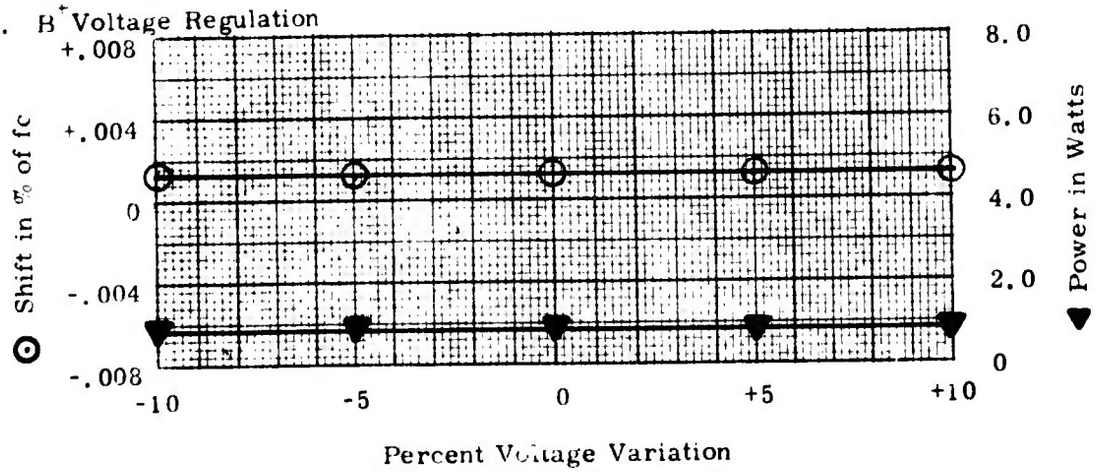
I. Time Drift



II. Temperature Stability



III. B+ Voltage Regulation



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make Conic, Type CTB-200-0.5H, Serial Number 200 B 277

Carrier Frequency fc 242.0 MHz. Date 6/8/76, By K.Y.L.

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
50	84 ± 3	fc - 4fx
121	109 ± 3	1/2fc
242.0	0	carrier frequency
774	90 ± 3	3fc + fc

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 5.35 watts
4. Efficiency 18.0%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
   Reverse polarity OK

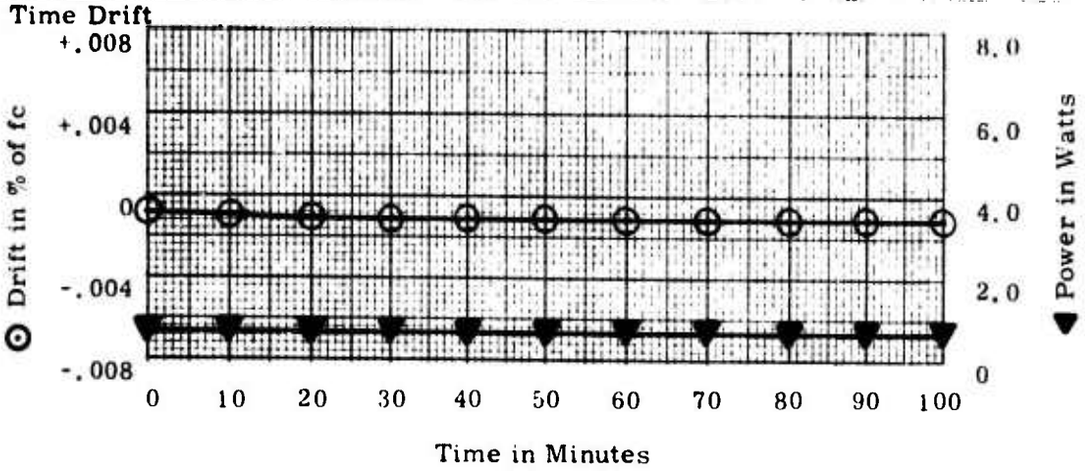
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

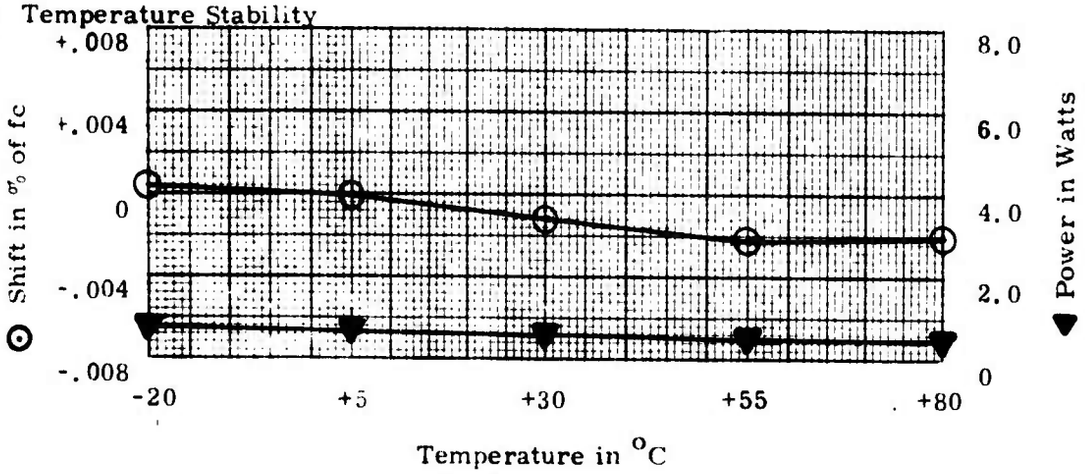
Make: CONIC ; Type: CTB-200-0.5H ; Serial Number: 200B279 ;

Carrier Frequency fc: 242.0 MHz, Date 6/30/76 ; By: KYL ;

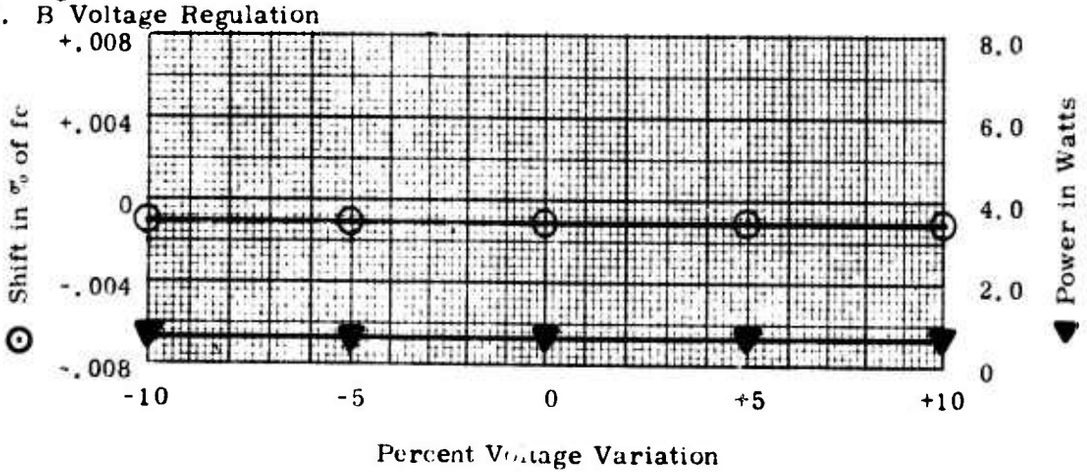
I. Time Drift



II. Temperature Stability



III. B+ Voltage Regulation



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic ; Type: CTB-200-0.5H ; Serial Number: 200 B 279 ;

Carrier Frequency fc: 242.0 MHz; Date: 6/30/76 ; By: K.Y.L. ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
82	72 ± 3	fc - 8fx
121	117 ± 3	1/2fc
162	82 ± 3	fc- 4fx
242.0	0	carrier frequency
262	80 ± 3	fc + fx
462	72 ± 3	fc + 11fx
484	112 ± 3	2fc
524	98 ± 3	2fc + 2fx
544	72 ± 3	2fc + 3fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.51 watts
4. Efficiency 16%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with V.S.W.R.
   Reverse polarity OK

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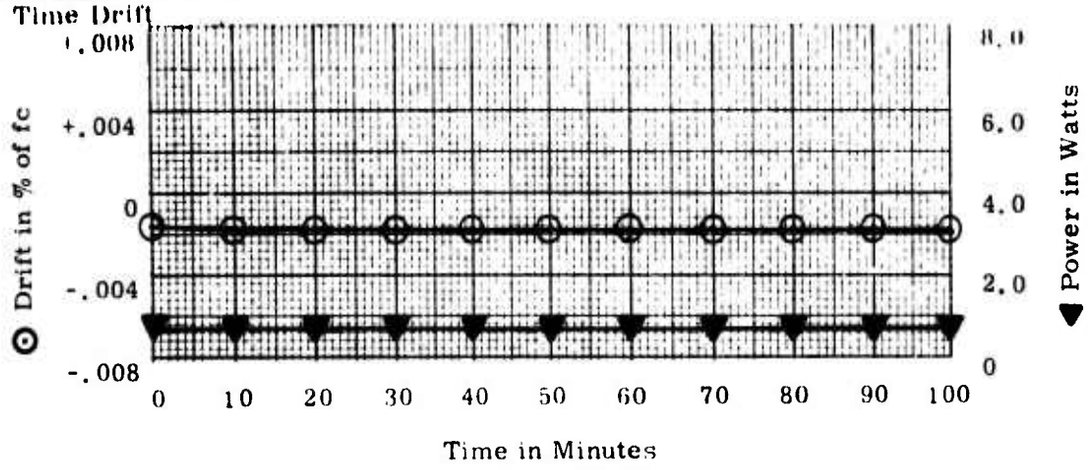
Evaluation Tests - RF Telemetry Transmitter - Sheet 1

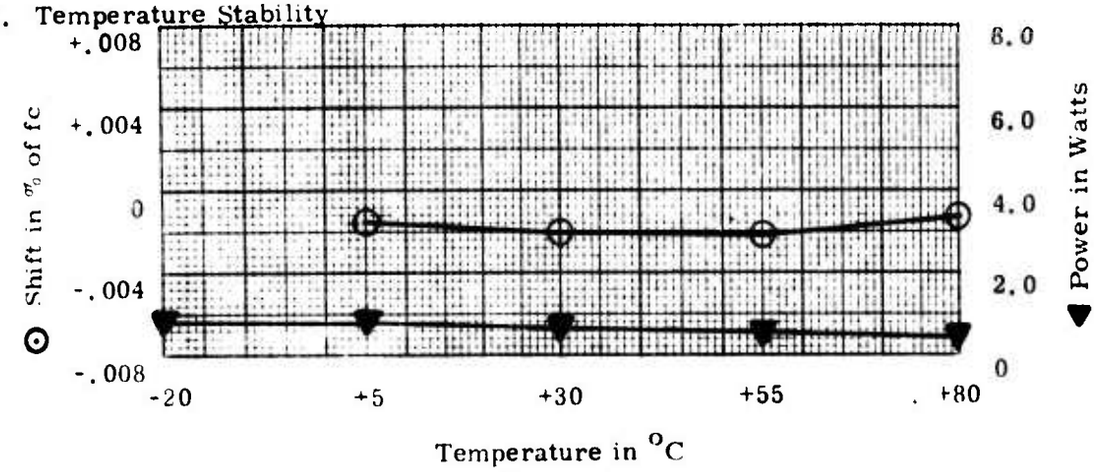
Make: CONIC, Type: CTB-200-0.5H, Serial Number: 200B280

Carrier Frequency fc: 242.0 MHz, Date: 6/29//6, By: KYL

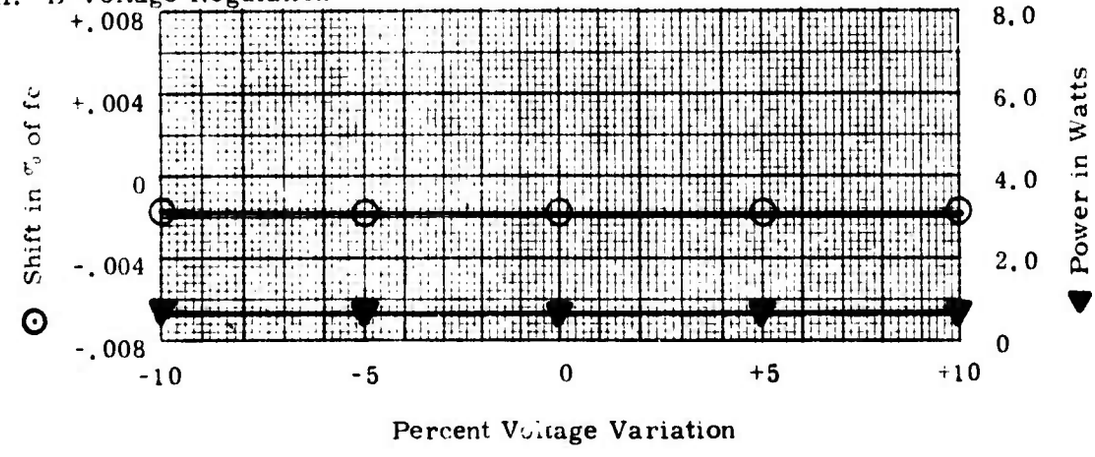
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Conic, Type: CTB-200-0.5H, Serial Number: 200 B 280;

Carrier Frequency fc: 242.0 MHz Date: 6/29/76; By: K.Y.L.;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
All spurious	emmisions meet Specif	ications

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.96 watts
4. Efficiency 15%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
   Reverse polarity OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Conic; Type: CTP - 402;

Manufacturer's Specifications

Frequency Range	Crystal Controlled (single frequency) VHF Telemetry Band 225 - 260 MHz.
Center Frequency Stability	0.01% under environmental operating conditions.
Power Output	2 watts minimum - terminated into 50 ohms with 28 ± 4 Vdc supply over specified temperature range.
Carrier Deviation	± 250 kHz
Modulation Characteristics	
Type	FM
Deviation Sensitivity	up to ± 150 kHz/volt p-p (factory set)
Input Impedance	10 K ohms resistive minimum, shunted by 30 pf
Frequency Response	± 1.5 dB from 10 Hz to 500 kHz
Power Requirements	28 ± 4 Vdc at 450 milliamperes maximum
Radio Frequency Interference	Satisfies the requirements of IRIG 106-69 for antenna conducted and radiated and MIL - I - 26600 for box power line conducted and radiated.
Temperature	- 30°C to +80°C, MIL-STD-810 as follows: Low Temperature, Method 502 High Temperature, Method 501 Temperature Shock, Method 503
Humidity	MIL-STD-810, Method 507
Acceleration	100 g's in each direction of any three mutual perpendicular axes.
Shock	100 g's 11 millesecond duration (half sine pulse) in each direction of any three mutually perpendicular axes.
Vibration	20 G peak sine (20-2000 Hz) or .3 G^2/cps random in any axis.
Weight	Less than 12 ounces.

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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic ; Type: CTB-200-0.5H ; Serial Number: 200 B 280 ;

Carrier Frequency fc: 242.0 MHz Date: 6/29/76 ; By: K.Y.L. ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
All spurious	emmisions meet Specif	ications

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10 log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion N/A
2. Incidental FM N/A
3. Power Requirement 4.96 watts
4. Efficiency 15%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R.
   Reverse polarity OK

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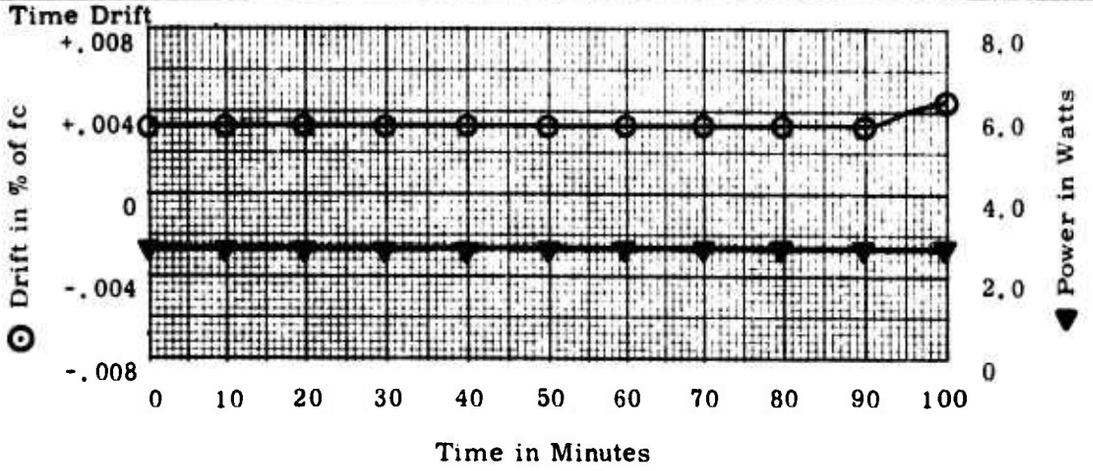
Evaluation Tests — RF Telemetry Transmitter — Sheet 1

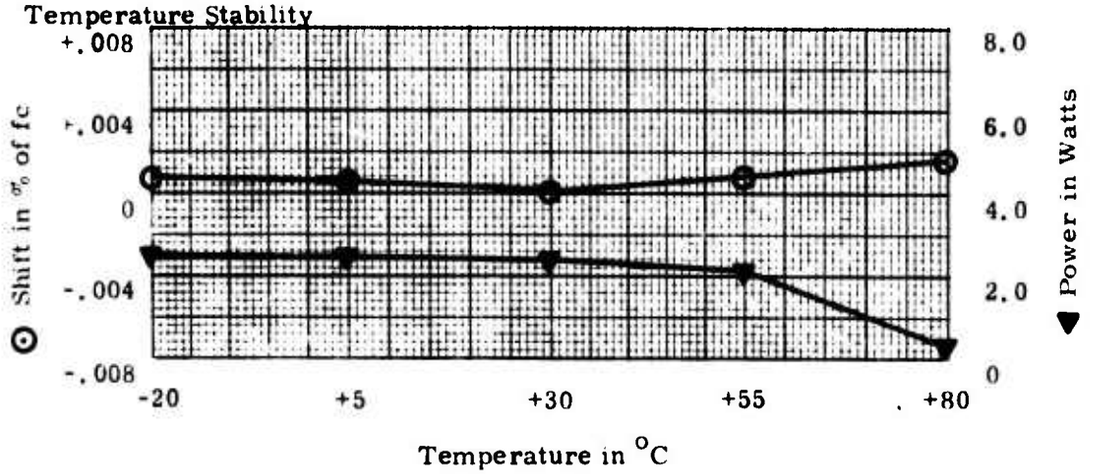
Make: Conic, Type: CTP 402, Serial Number: 402 P 192,

Carrier Frequency fc: 234.0MHz, Date: 8/4/76, By: K.Y.L.,

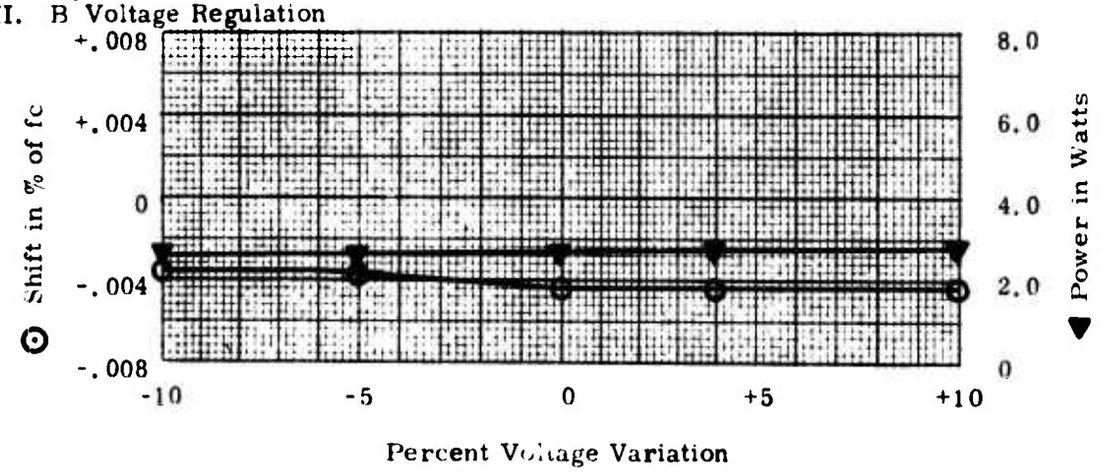
I. Time Drift



II. Temperature Stability



III. B+ Voltage Regulation

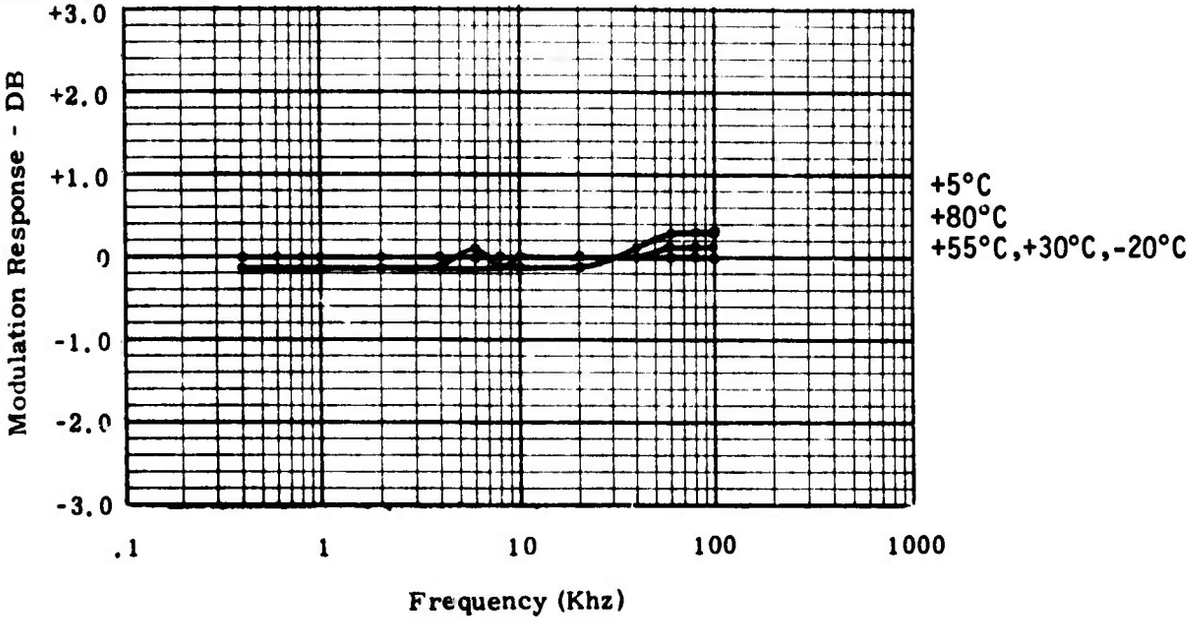


NORTHEASTERN UNIVERSITY

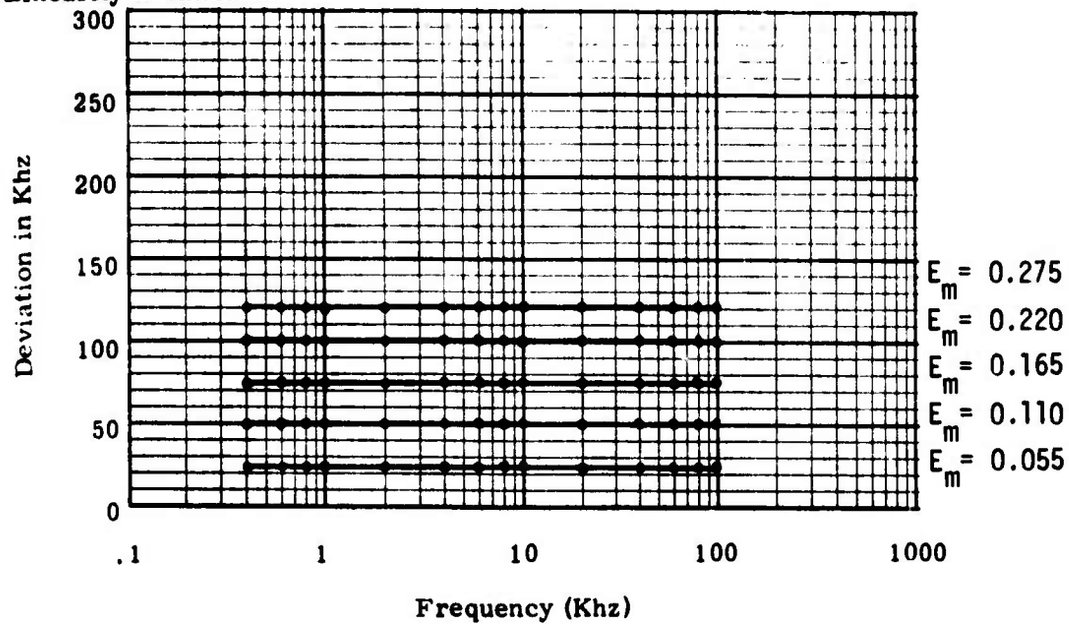
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Conic ; Type: CTP 402 ; Serial Number: 402 P 192 ;
Carrier Frequency fc: 234.0 MHz; Date: 8/4/76 ; By: K.Y.L. ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Conic ; Type: CTP 402 ; Serial Number: 402 P 192 ;

Carrier Frequency fc: 234.0 MHz; Date: 8/4/76 ; By: K.Y.L. ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
178	53 ± 3	fc - 28fx
188	45 ± 3	fc - 23fx
224	41 ± 3	fc - 5fx
228	35 ± 3	fc - 3fx
234.0	0	carrier frequency
278	46 ± 3	fc + 22fx
282	67 ± 3	fc + 24fx
286	66 ± 3	fc + 26fx
468	44 ± 3	2fc

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10 log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion 1.5%
2. Incidental FM <500 Hz Peak
3. Power Requirement 9.8 watts
4. Efficiency 27.6%
5. O.C. & S.C. Protection OK
6. Other Checks No carrier shift with 5:1 V.S.W.R. Reverse polarity OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector; Type: T105S;

Manufacturer's Specifications

RF Power Output	5 watts minimum into 50 ohm load with VSWR up to 1.5:1.
RF Load	Stable operation into any load impedance. Output circulator allows continuous operation into open or short circuit.
Output Frequency	Crystal controlled center frequency for S-band (between 2200-2300 MHz).
Output Frequency Stability	± 0.003% of specified, including setting tolerance and drift due to environment.
Harmonic and Spurious Outputs	In accordance with IRIG 106-69
Modulation Type	FM (PM available).
Input Impedance	50 ohms to 100 kilohm.
Deviation Sensitivity	up to ±750 kHz/volt rms.
Frequency Response	DC to 1 MHz ± 1.0dB.
Deviation Capability	± 900 kHz maximum.
Linearity	1.0% maximum, best straight line for; ± 750 kHz deviation.
Total Harmonic Distortion	1.0% maximum for; ±500 kHz deviation.
Input Voltage	28 ± 4 volts. Reverse polarity protection provided.
Input Current	2.0 A maximum.
Weight	16 oz. maximum.
Vibration	Sinusoidal at 20 g from 20 to 200 cps in each axis.
Shock	1/2 sine at 50g fro 11 milliseconds in each axis.
Altitude	Unlimited.

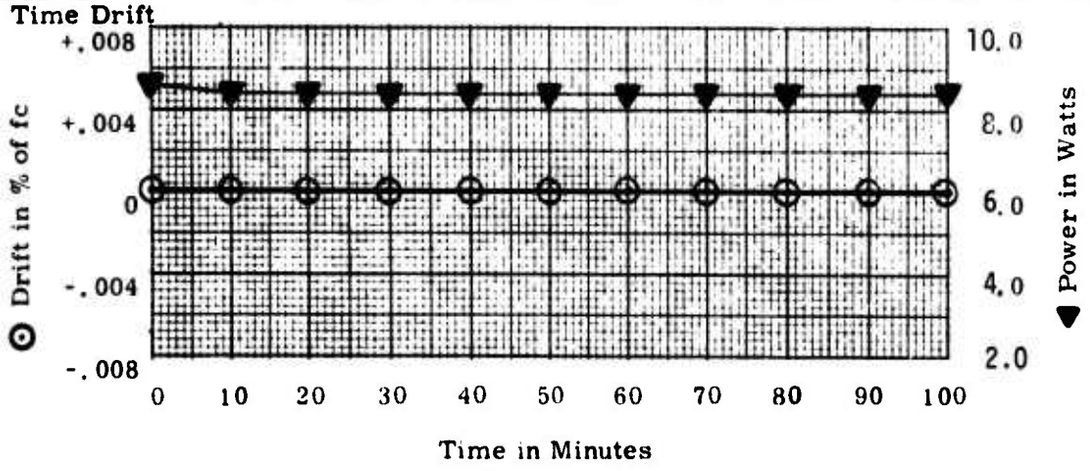
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

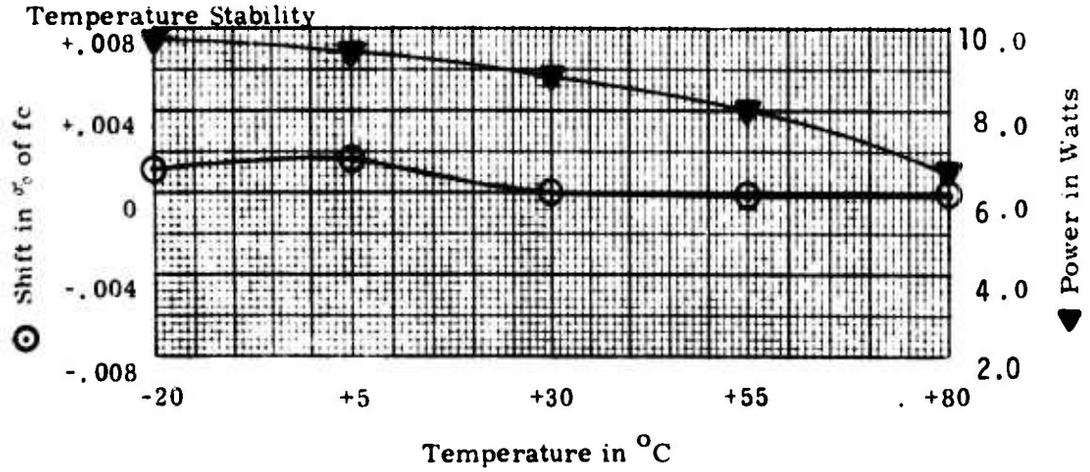
Make: Vector ; Type: T105S ; Serial Number: 1959 ;

Carrier Frequency fc: 2279.5 MHz; Date: 9/27/76 ; By: KYL & JLW ;

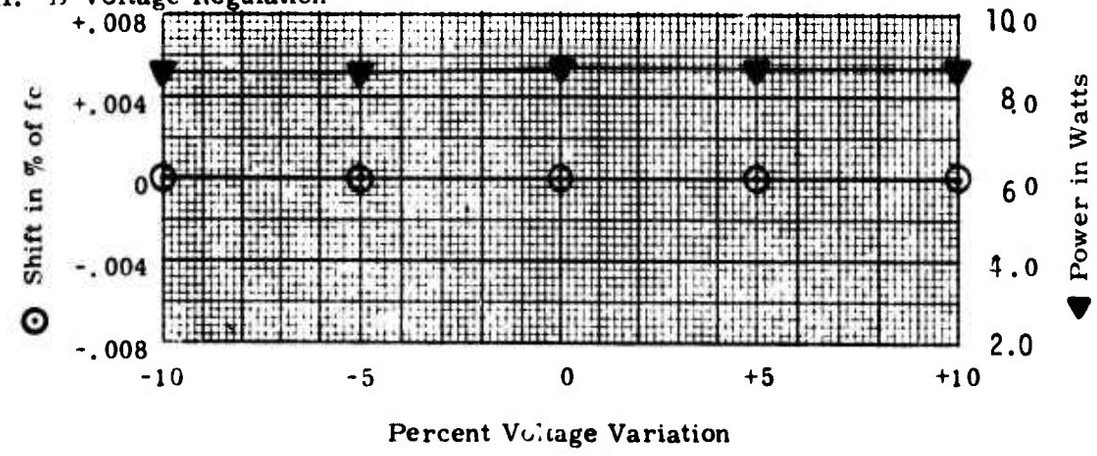
I. Time Drift



II. Temperature Stability



III. B+ Voltage Regulation



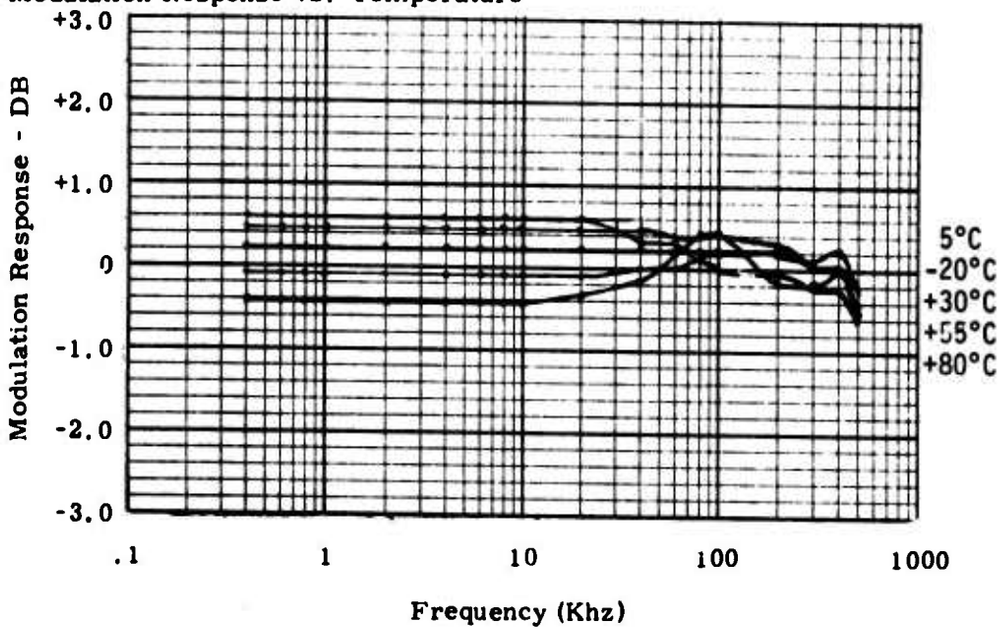
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 2

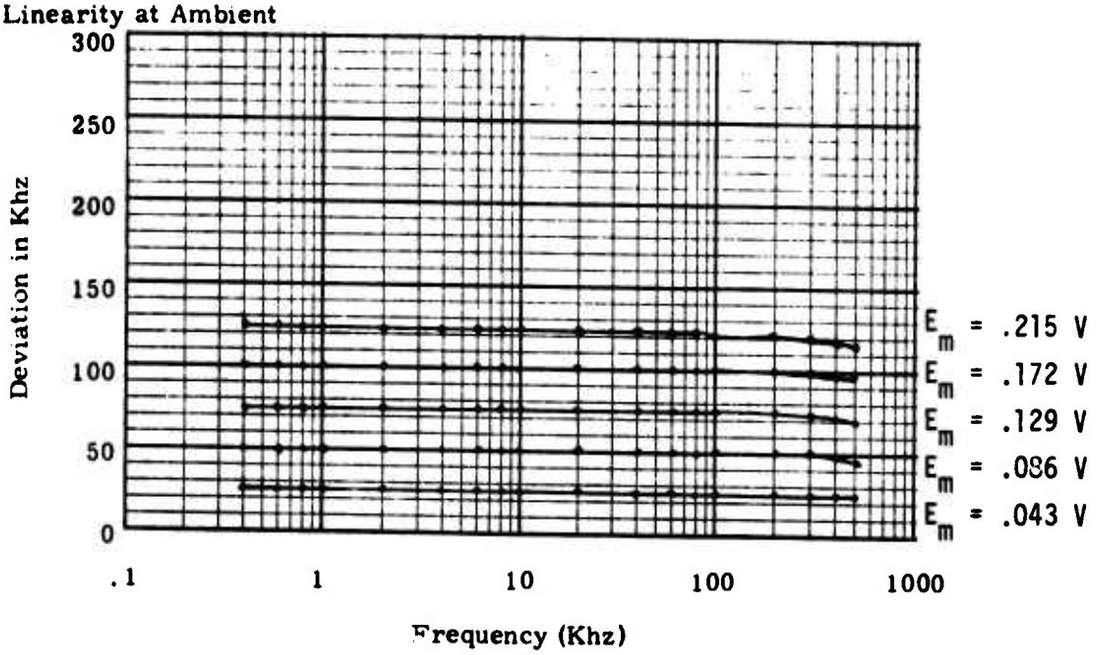
Make: Vector ; Type: T105S ; Serial Number: 1959 ;

Carrier Frequency fc: 2279.5 MHz. Date: 9/27/76 ; By: KYL & JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Vector ; Type: T105S ; Serial Number: 1959 ;

Carrier Frequency fc: 2279.5 MHz; Date: 9/27/76 ; By: KYL & JLW ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2.219.5	78 ± 3	fc - 3fx
2.239.5	93 ± 3	fc - 2fx
2.259.5	64 ± 3	fc - fx
2.279.5	0	carrier frequency
2.299.5	66 ± 3	fc + fx
2.339.5	88 ± 3	fc + 3fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10\log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.0%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 51.8 watt
4. Efficiency 18.73%
5. O.C. & S.C. Protection OK
6. Other Checks 5:1 VSWR Test = OK
   Reverse polarity = OK

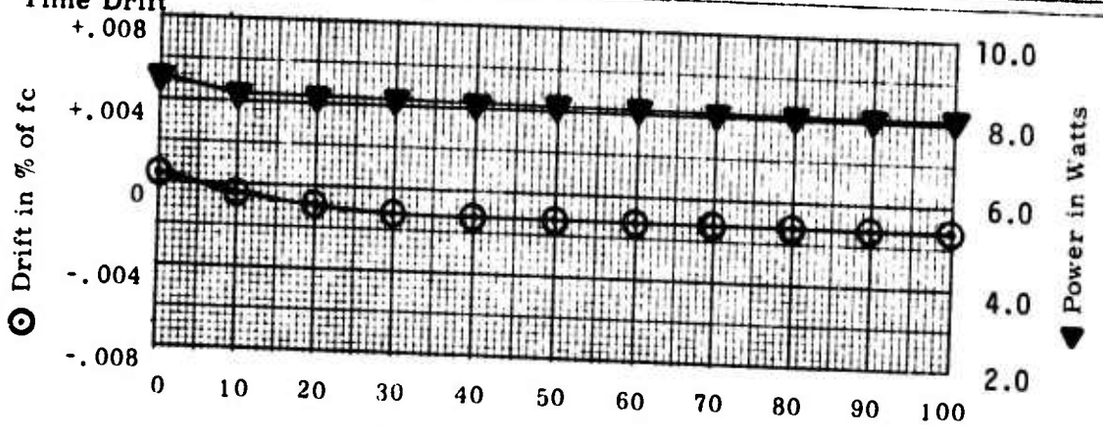
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

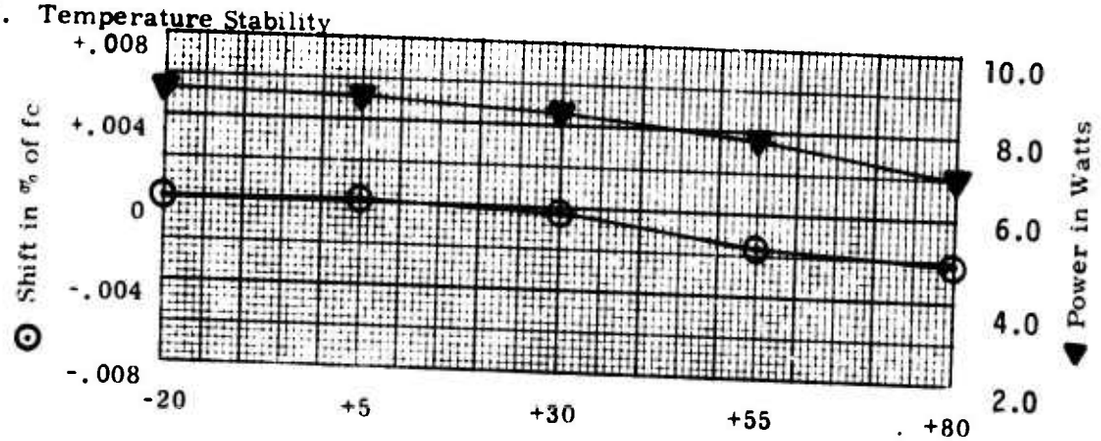
Make: Vector ; Type: T105S ; Serial Number: 1960 ;

Carrier Frequency fc: 2279.5 MHz; Date: 9/23/76 ; By: JLW ;

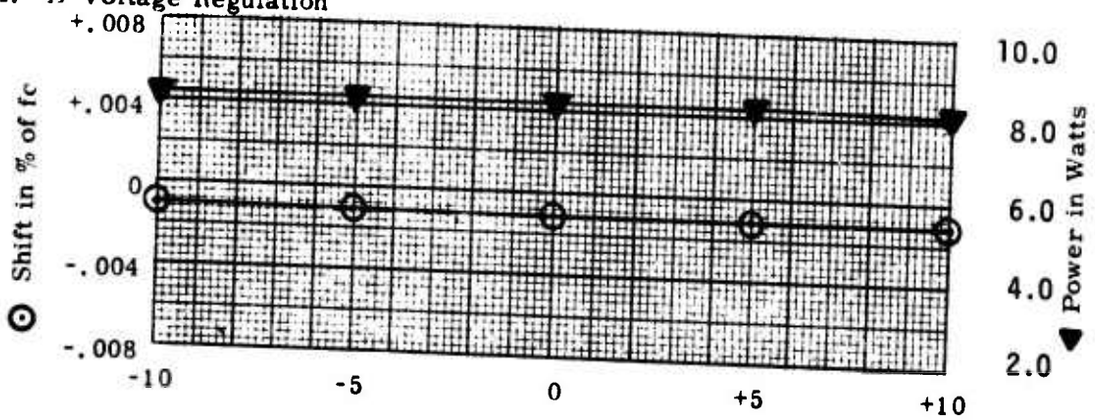
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation



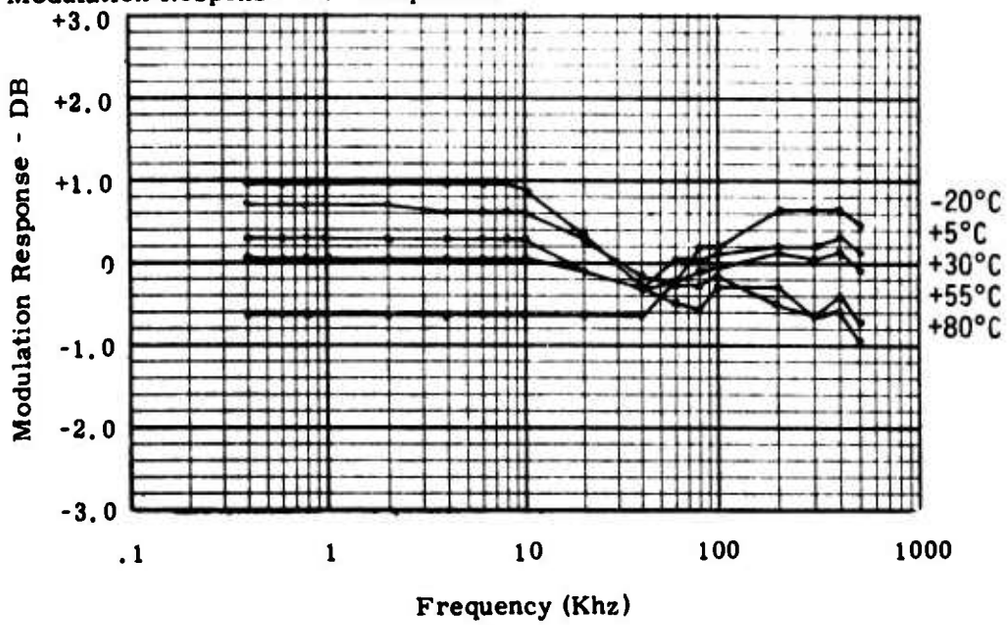
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 2

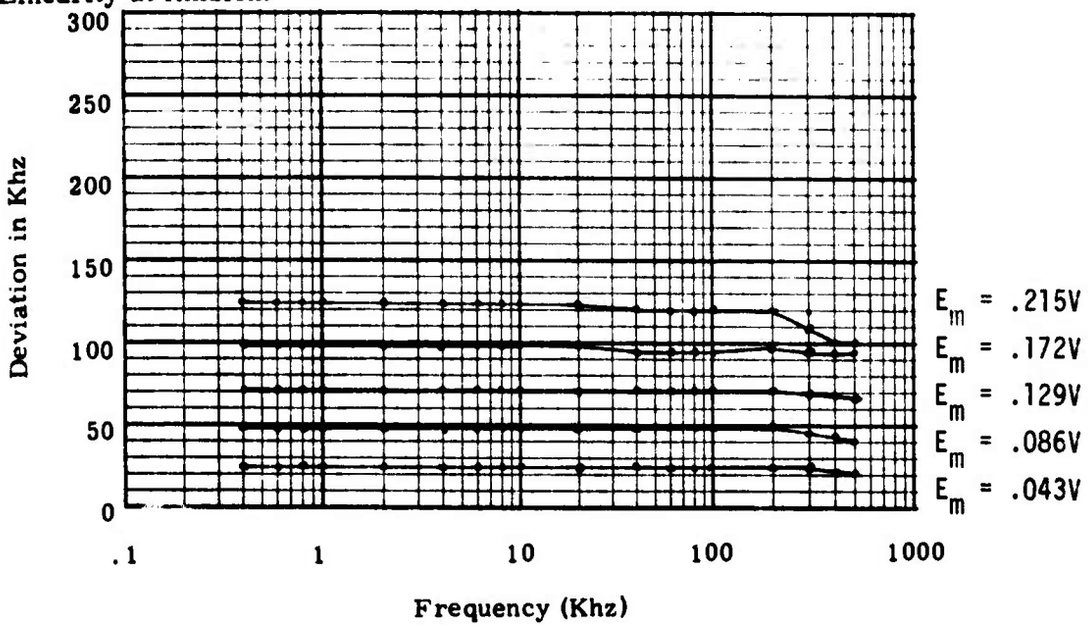
Make: Vector ; Type: T105S ; Serial Number: 1960 ;

Carrier Frequency fc: 2279.5 MHz; Date: 9/23/76 ; By: JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: Vector ; Type: T105S ; Serial Number: 1960

Carrier Frequency fc: 2279.5 MHz. Date: 9/23/76 ; By: JLW

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2218.0	74 ± 3	fc - 3fx
2238.5	81 ± 3	fc - 2fx
2259.0	76 ± 3	fc - fx
2279.5	0	carrier frequency
2300.0	78 ± 3	fc + fx
2320.5	87 ± 3	fc + 2fx
2341.0	80 ± 3	fc + 3fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10 log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.8%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 49 watts
4. Efficiency 17%
5. O.C. & S.C. Protection OK
6. Other Checks Reverse Polarity OK
   5:1 VSWR OK

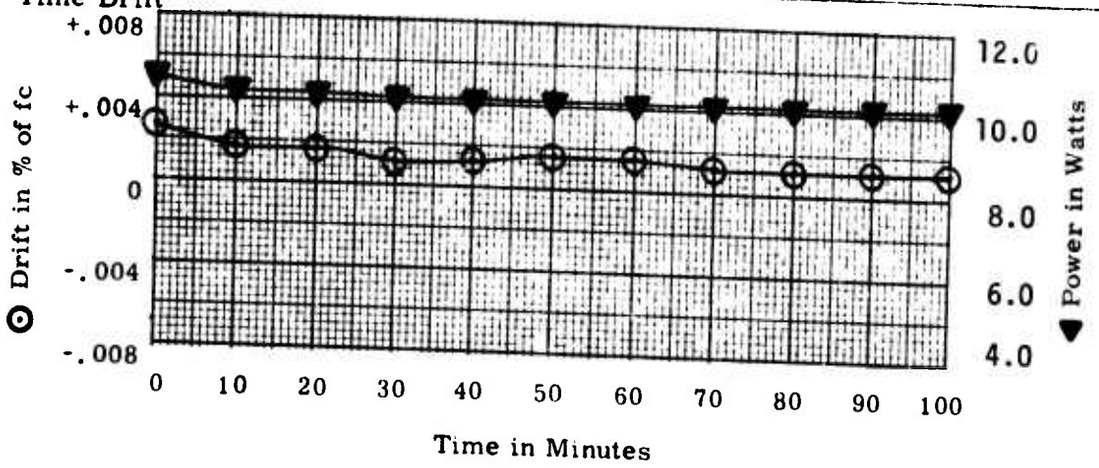
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

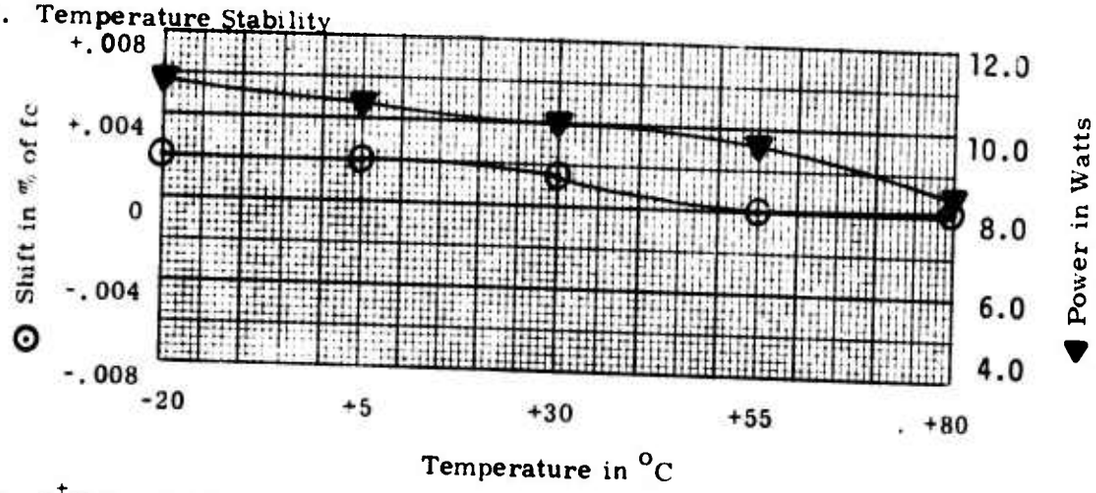
Make: Vector ; Type: T105S ; Serial Number: 2037 ;

Carrier Frequency fc: 2215.5 MHz; Date: 10/5/76 ; By: JLW ;

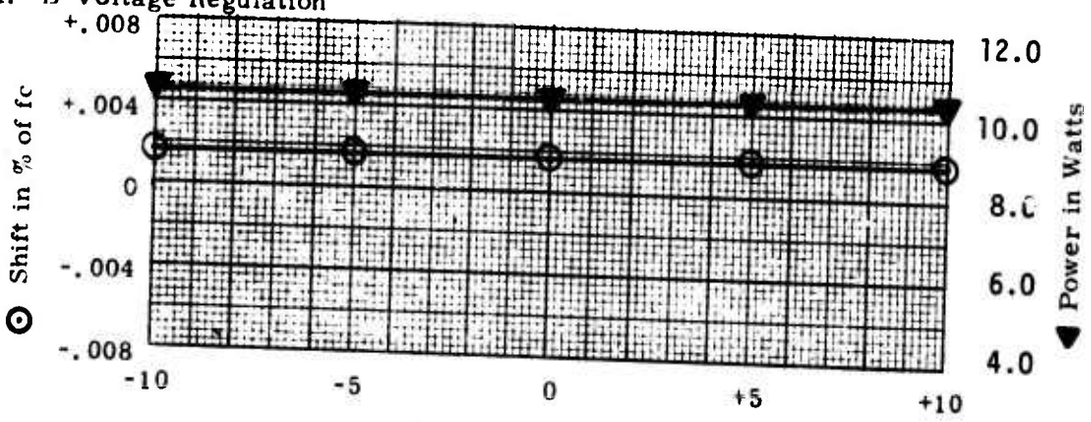
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation

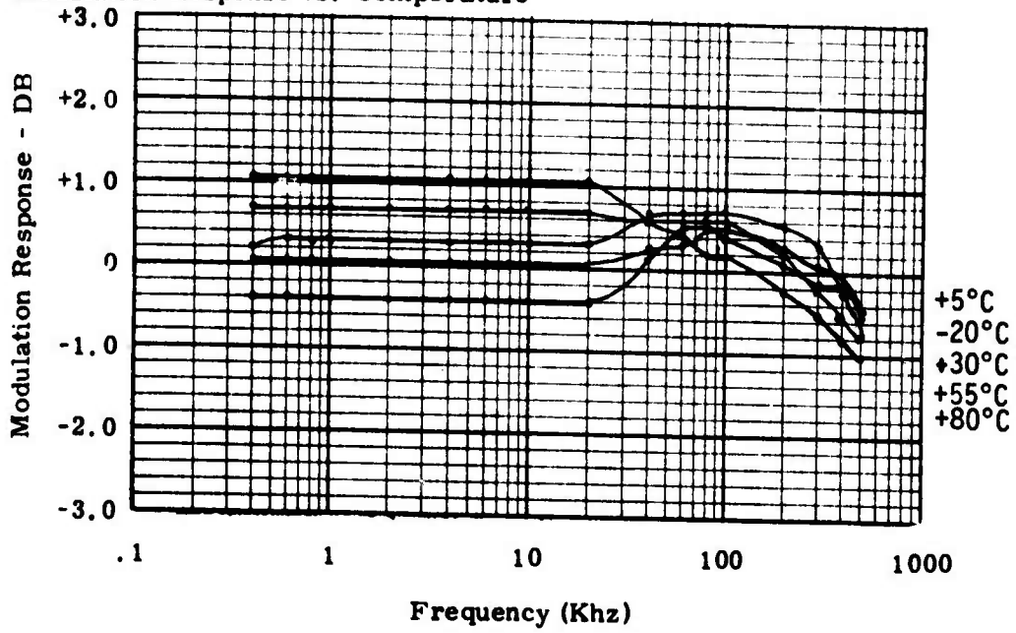


NORTHEASTERN UNIVERSITY

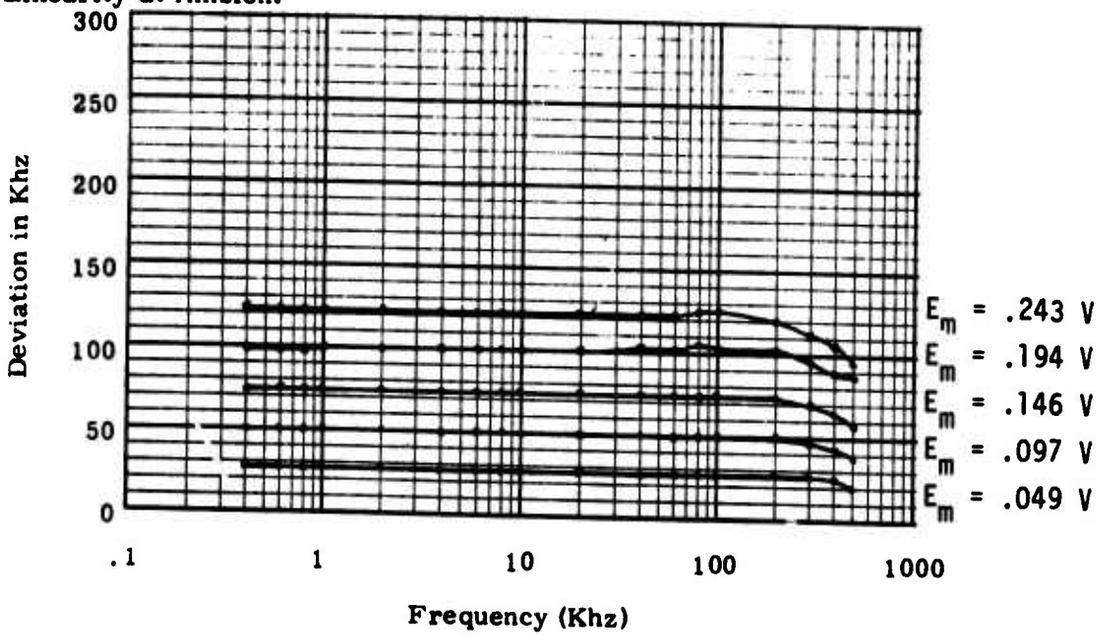
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T105S ; Serial Number: 2037 ;
Carrier Frequency fc: 2215.5 MHz; Date: 10/5/76 ; By: JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Vector ; Type: T105S ; Serial Number: 2037 ;

Carrier Frequency fc: 2215.5 MHz; Date: 10/5/76 ; By: JLW ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2155.5	75 ± 3	fc - 3fx
2175.5	84 ± 3	fc - 2fx
2195.5	79 ± 3	fc - fx
2215.5	0	carrier frequency
2235.5	84 ± 3	fc - fx
2256.5	88 ± 3	fc + 2fx
2275.5	79 ± 3	fc + 3fx
2955.5	66 ± 3	fc + 37fx
3695.5	63 ± 3	fc + 74fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10 \log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.50%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 50.40 watts max
4. Efficiency 21.43% max
5. O.C. & S.C. Protection OK
6. Other Checks Reverse voltage Test OK
   5:1 VSWR Test OK

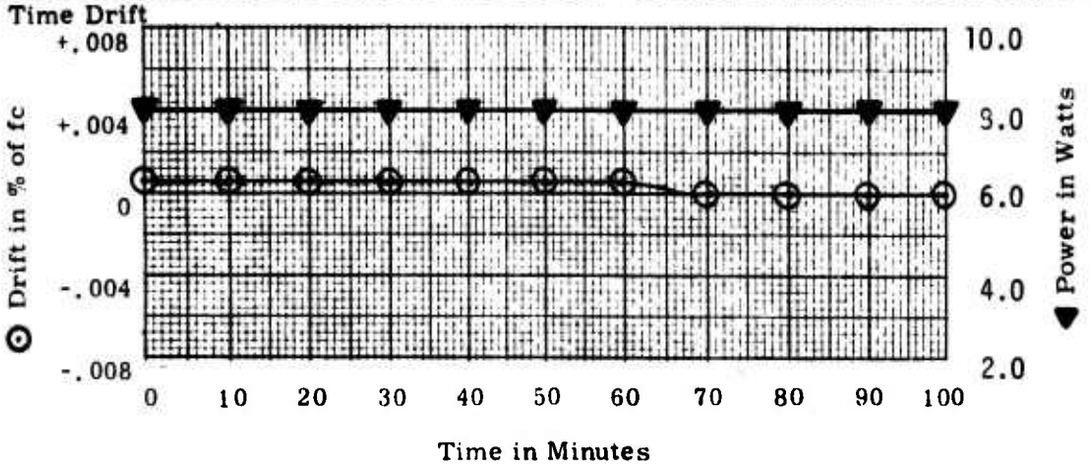
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

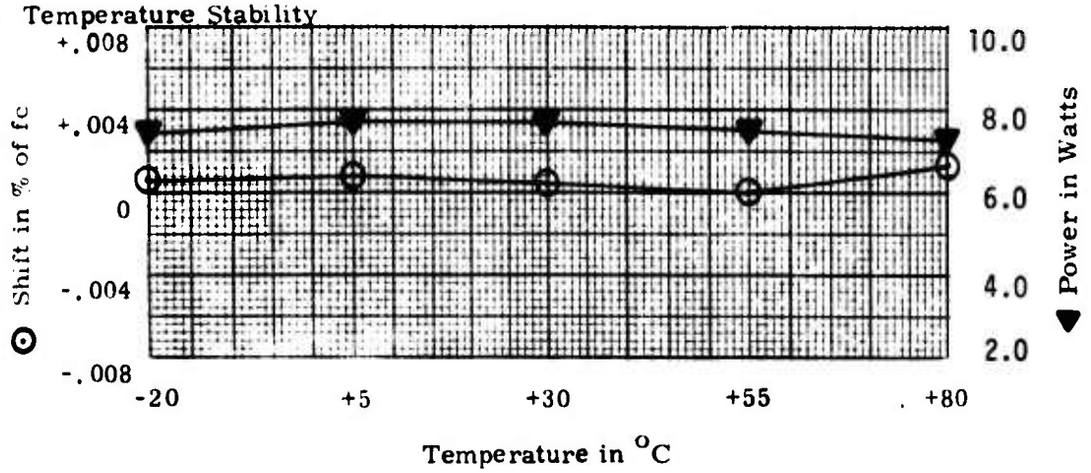
Make: Vector ; Type: T105S ; Serial Number: 2039 ;

Carrier Frequency fc: 2215.5 MHz, Date: 10/1/76 ; By: KYL & JLW ,

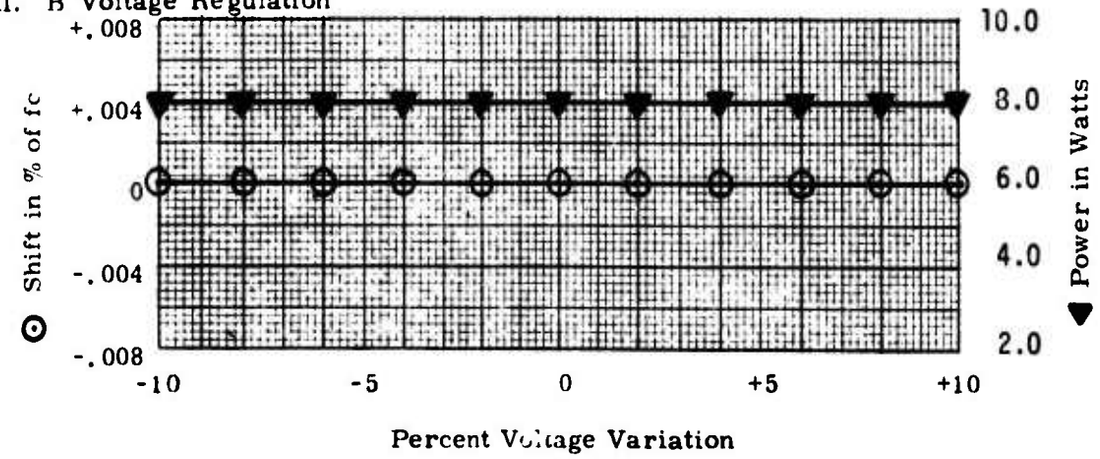
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation

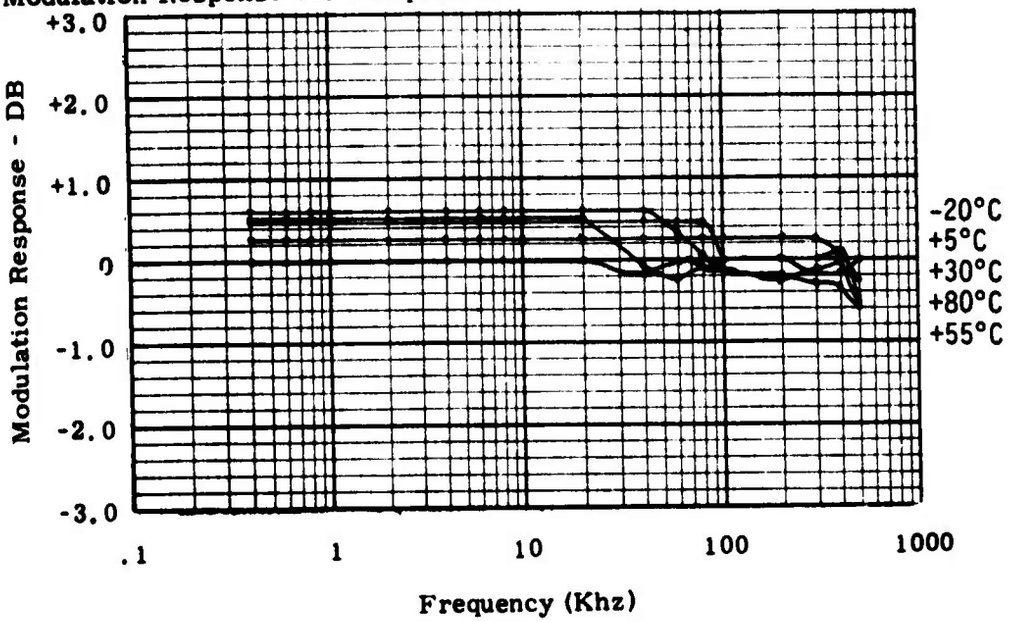


NORTHEASTERN UNIVERSITY

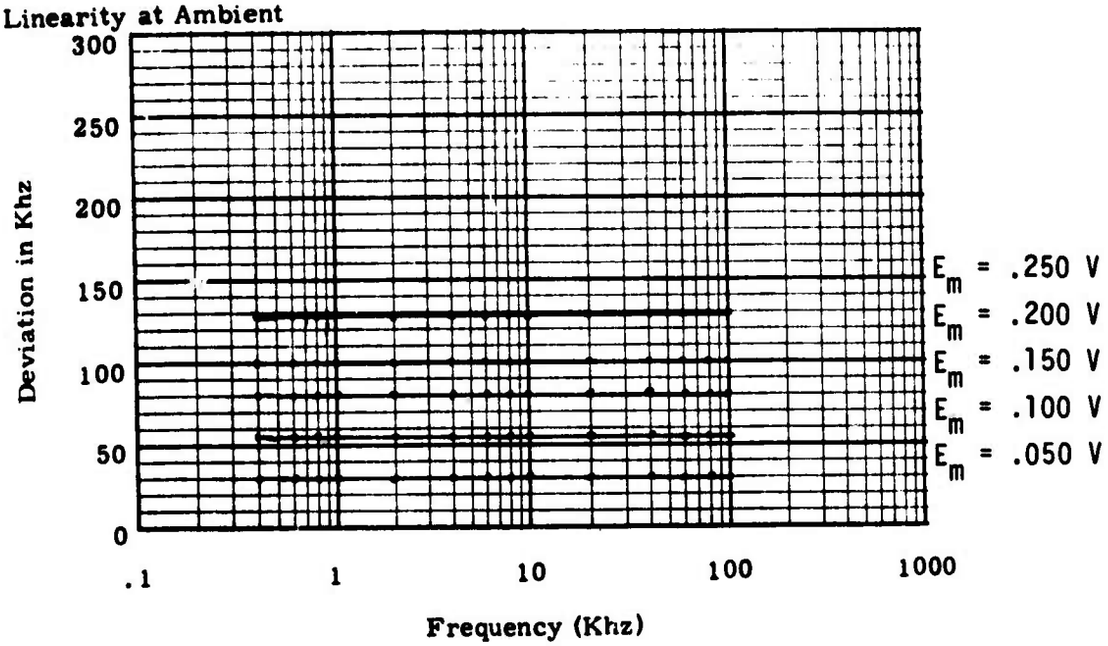
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T105S ; Serial Number: 2039 ;
Carrier Frequency fc: 2215.5 MHz; Date: 10/1/76 ; By: KYL & JLW ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests RF Telemetry Transmitter - Sheet 3

Make: Vector ; Type: T105S . Serial Number: 2039 ;

Carrier Frequency fc: 2215.5 MHz; Date: 10/1/76 ; By: KYL & JLW ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2155.5	92 ± 3	fc - 3fx
2195.5	83 ± 3	fc - fx
2215.5	0	carrier frequency
2235.5	86 ± 3	fc + fx

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10\log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion <1.0%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 51.8 watts
4. Efficiency 15.25%
5. O.C. & S.C. Protection OK
6. Other Checks Reverse polarity OK
   5:1 VSWR Test OK

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector; Type: T110TV;

Manufacturer's Specifications

RF Power Output	10 watts minimum into 50 ohm load.
RF Load	Stable operation into any load impedance. Output circulator allows continous operation into open or short circuit.
Output Frequency	Factory set crystal controlled center frequency in the 1710 to 1850 MHz low S-band. Standard S and L band available.
Output Frequency Stability	±0.02% of specified, including setting tolerance and drift due to environment (±0.01% available).
Harmonic and Spurious Outputs	In accordance with IRIG 106-71.
Modulation Type	FM
Input Impedance	75 ohms standard.
Deviation Sensitivity	+6 MHz/volt rms standard, higher deviation sensitivity available.
Frequency Response	10 Hz to 6 MHz ±1.5dB, up to 10 MHz available. Pre-emphasis in accordance with CCIR-405 optional.
Deviation Capability	±6 MHz maximum.
Linearity	2.0% maximum, best straight line; ±5 MHz deviation.
Total Harmonic Distortion	2.0% maximum for ±5 MHz deviation.
Baseplate Temperature	-20^{o} to $+70^{o}$C.
Vibration	Sinusoidal at 20g from 20 to 2000 cps in each axis.
Acceleration	100 g, each axis.
Altitude	Unlimited.

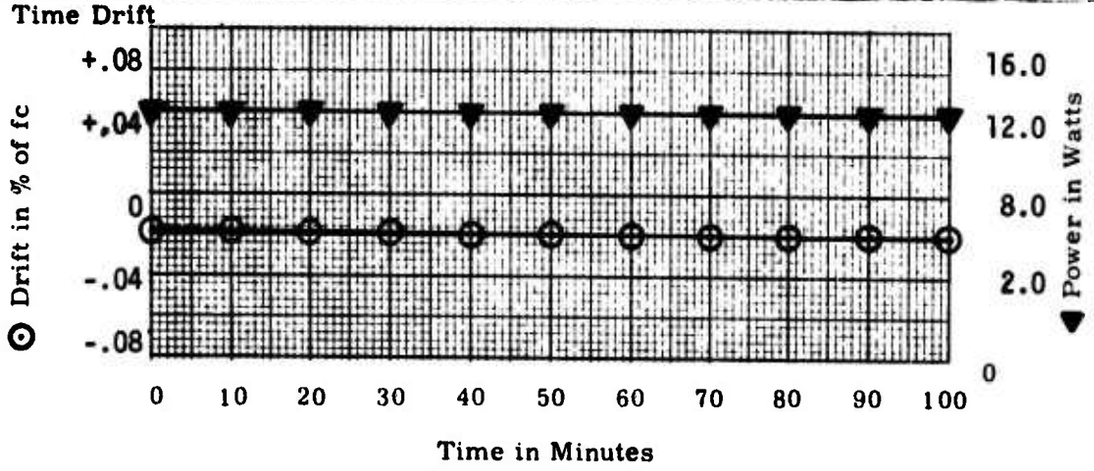
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

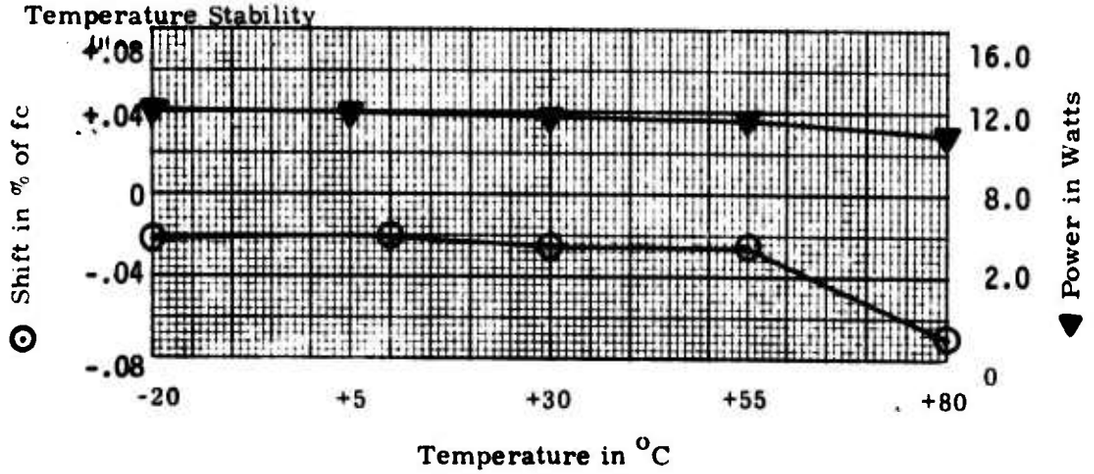
Make: VECTOR ; Type: T110TVS ; Serial Number: 1819 ;

Carrier Frequency fc: 2215.5 MHz; Date: 7/14/76 ; By: KYL ;

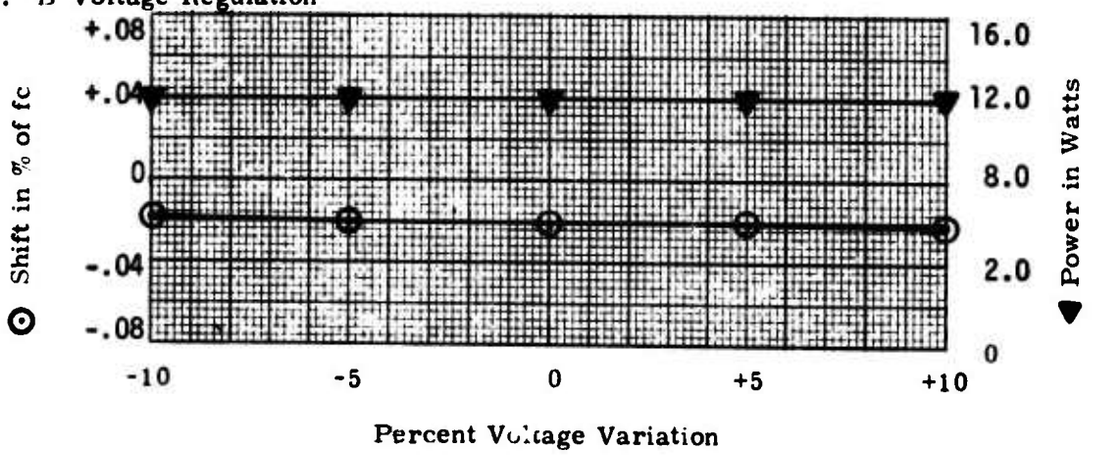
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation

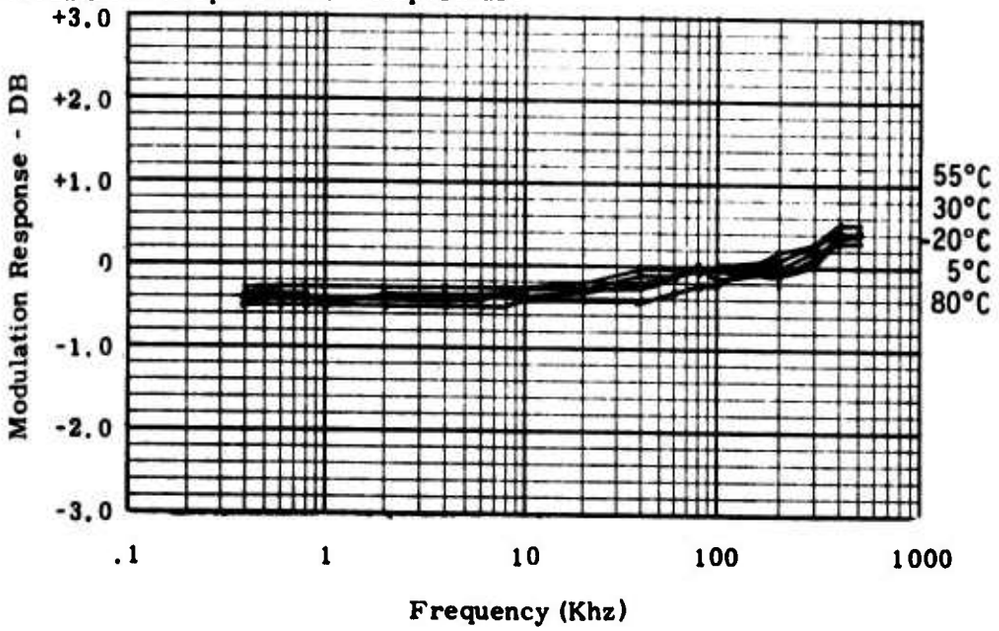


NORTHEASTERN UNIVERSITY

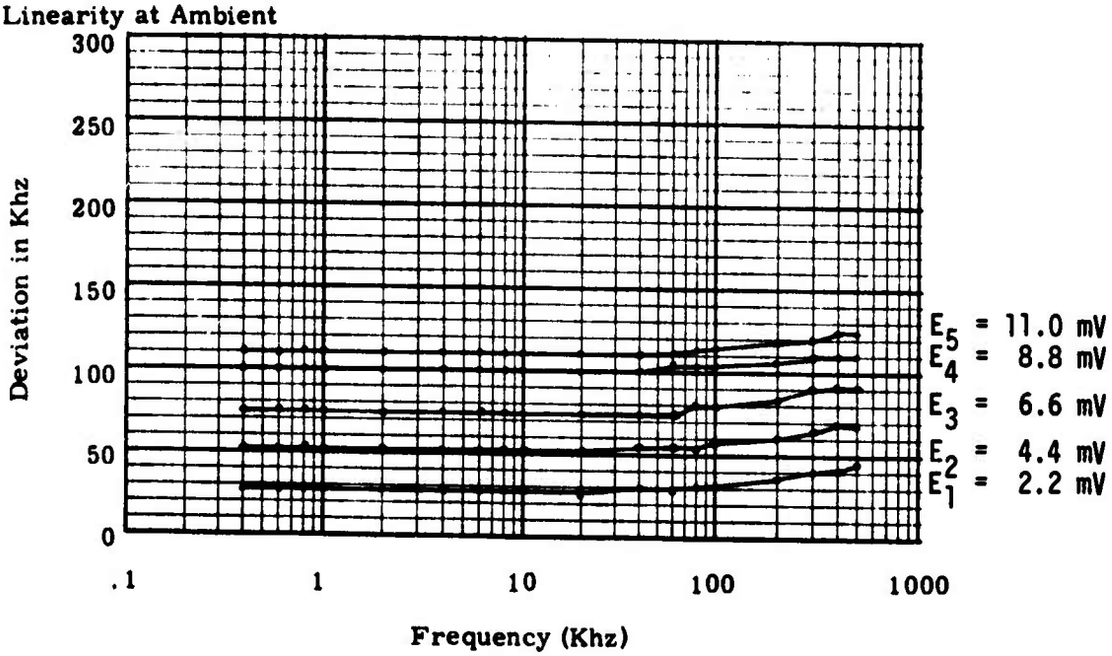
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: Vector ; Type: T110TVS ; Serial Number: 1819 ;
Carrier Frequency fc: 2215.5 MHz; Date: 7/14/76 ; By: KYL ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: VECTOR ; Type: T110TVS ; Serial Number: 1819 ;

Carrier Frequency fc: 2215.5 MHz; Date: 7/14/76 ; By: KYL ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
5170.0	91 ± 3	7/3 fc
4430.0	102 ± 3	2 fc
2215.5	0	carrier frequency
1476.0	65 ± 3	2/3 fc

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is 55+10 log P_t DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion < 1.85%
2. Incidental FM < 500 Hz PEAK
3. Power Requirement 106.4 watts
4. Efficiency 11.23%
5. O.C. & S.C. Protection OK
6. Other Checks 5:1 VSWR Test OK.

Evaluation Tests - Proprietary Information Sheet

RF Telemetry Transmitters

Make: Vector; Type: T-202S;

Manufacturer's Specifications

RF Power Output	2 watts minimum into 50 ohm load with VSWR up to 1.5:1.
RF Load	Stable operation into any load impedance. Output circulator allows continuous operation into open or short circuit.
Output Frequency	Crystal controlled center frequency for S-band (between 2200-2300 MHz).
Output Frequency Stability	±0.003% of specified, including setting tolerance and drift due to environment.
Harmonic and Spurious Outputs	In accordance with IRIG 106-71.
Modulation Type	FM (PM available).
Input Impedance	50 ohms to 100 kilohm.
Deviation Sensitivity	Up to ±750 kHz/volt rms.
Frequency Response	DC to 1 MHz ±1.5dB.
Deviation Capability	±1000 kHz maximum.
Linearity	1.0% maximum, best straight line.
Total Harmonic Distortion	1.0% maximum for; ±500 KHz deviation.
Input Voltage	28±4 volts, with reverse polarity protection.
Input Current.	1.0 amp maximum.
Baseplate Temperature	$-25^{o}C$ to $+85^{o}C$
Vibration	Sinusoidal at 20g from 20 to 2000 cps in each axis.
Acceleration	100g, each axis.
Altitude	Unlimited.

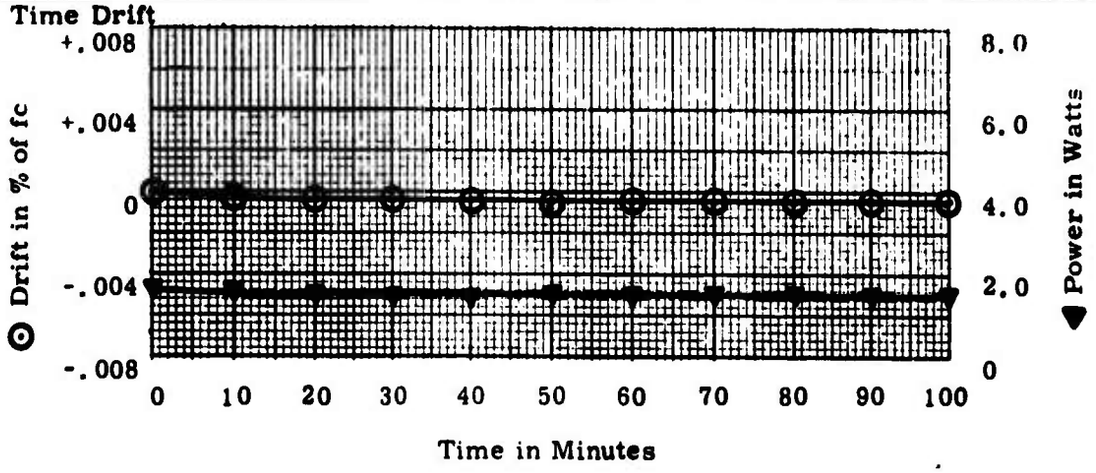
NORTHEASTERN UNIVERSITY

Evaluation Tests - RF Telemetry Transmitter - Sheet 1

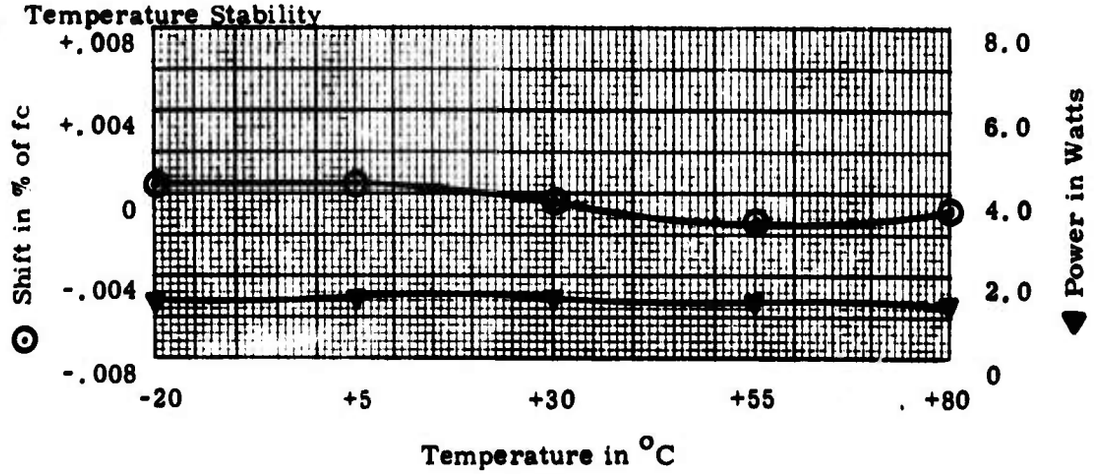
Make: VECTOR ; Type: T202S ; Serial Number: 312 ;

Carrier Frequency fc: 2251.5 MHz; Date: 6/25/76 ; By: KSB ;

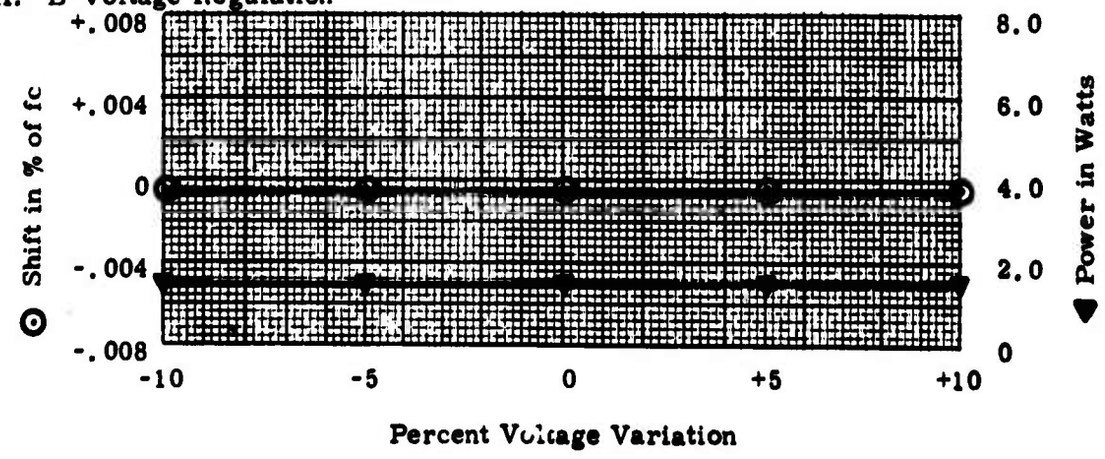
I. Time Drift



II. Temperature Stability



III. B^+ Voltage Regulation



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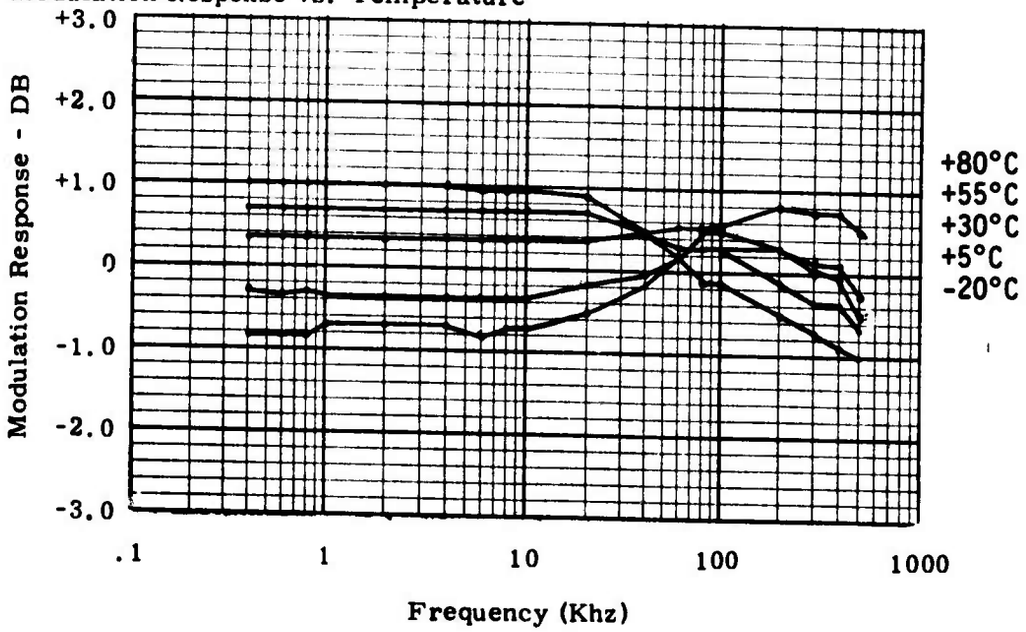
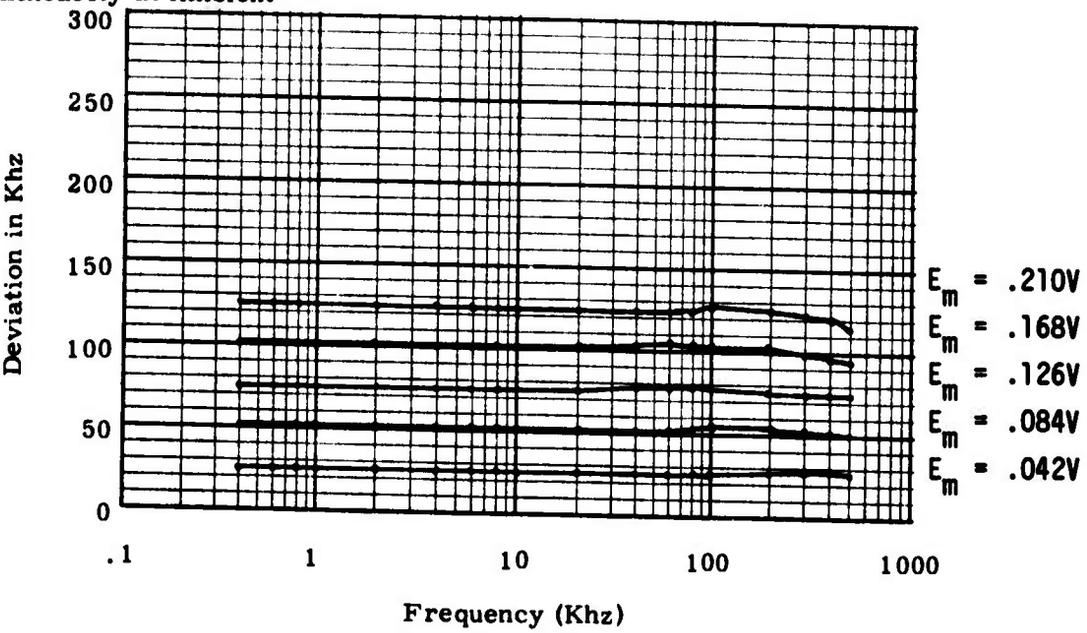
Evaluation Tests - RF Telemetry Transmitter - Sheet 2

Make: VECTOR ; Type: T202S ; Serial Number: 312 ;
Carrier Frequency fc: 2251.5 MHz; Date: 6/25/76 ; By: KSB ;

IV. Modulation Response vs. Temperature



V. Linearity at Ambient



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Evaluation Tests - RF Telemetry Transmitter - Sheet 3

Make: VECTOR ; Type: T202S ; Serial Number: 312 ;

Carrier Frequency fc: 2251.5 MHz; Date: 6/25/76 ; By: KSB ;

VI. Spurious Emission (Antenna Conducted)

Frequency Mhz	DB Down from fc	Identification
2132	77 ± 3	fc - 6fx
2152	105 ± 3	fc - 5fx
2191	73 ± 3	fc - 3fx
2212	90 ± 3	fc - 2fx
2232	79 ± 3	fc - fx
2251.5	0	carrier frequency
2272	81 ± 3	fc + fx
2292	90 ± 3	fc + 2fx
2312	66 ± 3	fc + 3fx
2352	102 ± 3	fc + 5fx
2372	76 ± 3	fc + 6fx
4503	84 ± 3	2fc

NOTE: W.S.M.R. Regulation No. 105-2-60 requirement is $55+10\log P_t$ DB Down from carrier.

VII. Miscellaneous

1. Maximum Distortion 1.95%
2. Incidental FM <500 Hz PEAK
3. Power Requirement 13.9 watts
4. Efficiency 11.0%
5. O.C. & S.C. Protection OK
6. Other Checks freq. at 5:1 VSWR = 2251.4895
   carrier shift = .0000% of fc at 5:1 VSWR

PERSONNEL

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